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JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

DEVOTED TO

MECHANICAL AND PHYSICAL SCIENCE,

Civil Engineering, the Arts and Manufactures.

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JULY, 1866.

CIVIL AND MECHANICAL ENGINEERING.

For the Journal of the Franklin Institute.

Grain Elevators, Cleaners, and Dryers. By ALFRED P. BOLLER, C. E.

The marvelous growth of the grain trade, during the last few years, has given rise to a department of construction for its handling, which it is the province of this paper to describe. To comprehend the necessity which resulted in the construction of grain elevators, it will, perhaps, be advisable to take a glance at this growth, and for that purpose the following statistics for the port of Buffalo are given. The amount of grain of all kinds brought to this port in 1840, was 1,075,-888 bushels; in 1841, 1,852,325 bushels; and in 1842, it had grown to 2,015,928 bushels, which last amount was quadruple that received in 1836, a period of but six years back. All this grain had to be transferred from vessels to canal boats, or stored in warehouses along the docks, by means of manual labor, cumbersome tubs or bags being used for that purpose. Besides being slow and expensive, detaining both lake vessels and canal boats a long time in port, the grain trade had so developed, as to make it reasonable, from past experience, to look forward to a time, and that, too, not far distant, when it would be impossible to handle, by the old methods, but a very small proportion of the grain that would be poured into the port of Buffalo, from the fast settling west and north-west, seeking that port as an outlet for the Atlantic States and Europe. In view of these facts, and in the face of the sneers and evil prophecies that always attend an innovation upon long established custom, Joseph Dart, Esq., proposed to construct an elevating warehouse, the motive power for which should be steam. Accordingly, a small one was built, 50 by 100 feet, with a

storage capacity for about 55,000 bushels of grain, and with a transfer capacity of a little over 600 bushels per hour. So great was the success of this experiment that the enterprising builder increased its capacity so as to store 110,000 bushels of grain. A new period was now inaugurated in the grain trade, springing from Mr. Dart's success. Three more elevators were speedily commenced, improving, of course, upon the original one. In 1847, the grain trade had reached about 17,000,000 bushels, ten times the amount that was received in 1841, which large increase taxed the then existing facilities almost beyond their powers. To handle the sixty odd million bushels of grain which Buffalo now receives each year, there are twenty-four elevating warehouses, capable of storing 5,000,000 bushels, and a total transfer capacity of 2,350,000 bushels per day. The average storage capacity of these elevators is about 250,000 bushels each.

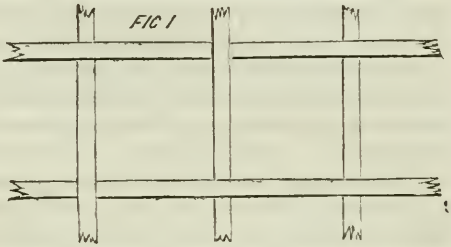
These warehouses are located upon the piers or docks, leaving sufficient room between them and the water's edge to allow a free passage way for drays and carts. This distance varies from 15 to 30 feet, surrounding circumstances, of course, regulating it. In plan, an elevator presents the appearance of a large rectangle, (formed by the outside walls,) broken up into numerous smaller ones, averaging from 10 to 12 feet square. These smaller rectangles are plans of the bins. When all the bins are full there is of necessity an immense weight to be supported. Some idea of this weight may be had from the fact that each 100,000 bushels of grain weighs 3000 tons, which would be for an elevator of 400,000 bushels capacity, 12,000 tons. It is easily seen how carefully the foundation for supporting such a weight must be prepared, and how guardedly any after-settling must be prevented.

From the necessitated location of grain warehouses on the wharves and piers, and the bottom being invariably mud and sand, there is but little choice for kind of foundation other than piles, upon which they are usually built. The piling, of course, must be most thoroughly done, and the piles should be driven as close together as it is possible to get them. They are cut off at least six inches below lowest water, and very carefully leveled. Upon the heads of the piles thus cut off, a course of heavy oak plank is spiked, upon which the masonry of first-class ashlar is laid in large blocks. The outside walls are usually carried up about 16 feet, at which height the bins are started. These walls are pierced at the required points by doors and windows. The intersections of the bins are supported by three heavy squared posts, forming piers, as it were, which posts are usually made from oak, beach, or elm, and are from 12 to 16 inches square. All these posts in each pier are in the same plane, one being vertical, the other two battering, like struts; the opposite struts of two adjoining corners have a heavy straining beam between them. Heavy parallel girders run across from wall to wall, resting at their intermediate points upon the piers and straining beam. Heavy cross joists run at right angles to these girders upon which the bins are started.

The sides of the bins are formed of plank laid flatwise, usually two inches thick and spiked, the spikes being long enough to reach

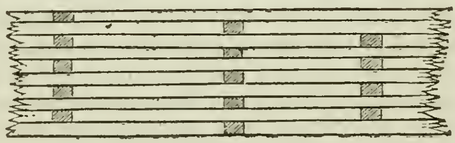
through two thicknesses of plank, and part way into a third. These bins are carried up to various heights, and, as before remarked, are usually 10 to 12 feet square. The lengths of planks are so arranged as to break joint with each other, the same plank often running through the distance of three and sometimes four bins. This arrangement frames all the bins together, and adds greatly to the stiffness in resisting the bulging tendency of the grain.

The accompanying Fig. 1 will better illustrate this construction, showing, as it does, a plan of two bins, with a portion of one side in elevation, (Fig. 2.) In the elevation are seen the planks laid together, and running through two or more compartments, breaking joint with each other.



The outside corners of bins constructed in this manner are further stiffened by clamps, and the outer sides resting immediately upon the walls forming the first story are made from wider plank. With the exception of the motive power itself, all the machinery for operating the elevator is located immediately upon the tops of the bins. There are at least two elevating "legs," as they are called, in any elevator, but they are multiplied according to the work to be performed and the size of the warehouse. These legs may be either "marine" or "house" legs. The marine leg is used to empty vessels, and is located in what is called a "tower," which is nothing more than a high projection from the main building. This tower has a free passage way under it, and is supported upon the extreme edge of the dock or pier by heavy square timber posts founded upon piles. The only entrance to the upper part of the building is through the tower, in which all the weighing is performed. Two strongly braced guides allow a vertical motion to this leg, while an outward motion is given to it by swinging it upon the axis of the head pulley, the slack in the driving belt that is caused by the varying position of the leg being taken up by means of tension pulleys, which will be described hereafter.

Fig. 2.



The "house leg," which is stationary inside the building, elevates the grain discharged by the marine leg into a hopper at its foot to the top of the house, where spouts distribute it to the various bins. These legs consist of two rectangular boxes of heavy plank connected at top and bottom, spread apart at the top in order to give sufficient room for the large "head pulley." An endless belt passes through these boxes and over a band wheel at either end.

At close intervals buckets, in form of quarter cylinders, are secured to this band, which dip up the grain as fast as it is fed to them. This is the simple construction of a steam elevator, but in the more modern built grain warehouses, it is usual to add conveniences for drying, cooling, and cleaning grain. Heretofore, much grain has been damaged by vessels encountering the sudden and heavy storms of the lakes, but now the perfect appliances of modern mechanical construction will save any cargo, no matter how wet it may be, if the vessel should make port in a reasonable time. Grain sometimes reaches the great entrepôt of Buffalo so mixed with chaff, sand, dust, and such like, the accumulation of hundreds of miles transportation by rail and water, that its value is very much impaired. Of course, an additional charge is made for both cleaning and drying grain thus injured, as its value is increased about twenty-five per cent. All these appliances will be described in connexion with the elevators to which they may be attached.

Before going into the details of elevator construction, let us take a glance at a few of the Buffalo and other lake port elevators, and, first of all, the

Sternberg Elevator.—This building is provided with fifty-six bins, 40 feet high, representing a storage capacity of 350,000 bushels of grain. The foundations for the outer wall consist of three hundred and sixty piles, driven three abreast, the minimum diameter of piles at top being 12 inches. Each pier or set of posts is supported upon nine piles. The outside walls are started on the piles 4 feet wide, and in courses of two feet thick. These walls are stepped off to a width of 2 feet 6 inches in a height of 6 feet. The wall is carried up of that width to the bottom of the bins, an elevation of 14 feet. This wall is undressed ashlar, laid in courses 2 feet 4 inches in thickness, every third stone being a header. The piers are built of large single stones resting upon the piles, the lowest stones being 4 feet square and 2 feet thick. These stones diminish in size in a height of 6 feet, to the capping stone, 12 inches thick, and 2½ feet by 3 feet. The heavy timbers that immediately support the bins are placed upon, and bear against, the capping stones. The above-described lower story is pierced by five doors and seven windows, the shutters for which are wrought iron. As before remarked, the bins are 40 feet high and 10 feet square, built of two-inch plank laid flatwise, and start from the coping of the outer walls, and the cross girders supported by the posts on each pier. The planking composing the outside walls is 9 inches wide half way up, and 8 inches the other half. The divisions of the bins are formed of plank, 7 inches wide one-third up, 6 inches one-third, and 5 inches the other third. All the planking is nailed together with spikes reaching through two thicknesses and one inch into the third. At all intersections or crossing of corners, there are three spikes driven as additional security. All outside corners are clamped by means of iron straps, one-half by 4 inches, hooked down at the ends and securely spiked. These clamps are put every 18 inches one-half the height of the bins. For convenience of getting down into the bins, each bin has

a ladder in one corner of round iron. The bottoms of the bins are hopper-shaped in two directions, and are supported upon joists 7 inches apart, except the two nearest the centre, which are 12 inches apart, to allow sufficient room for the discharge spout with its slide to regulate the flow of the grain. The flooring forming the bottoms of the bins is made in two courses of inch boards. On the top of the bins, a main run-way is laid, passing entirely through the centre of the building, from which smaller ones diverge, so as to reach the several bins. The operating engine is located in a small fire-proof building alongside the elevator warehouse, the brick smoke-stack being carried up beyond the highest point of the building. One bin space is left vacant in order to permit the main driving belt to be taken up to the band wheel situated on top of the bins. From this point the power is transmitted to the belts working the inside or house leg, and also the outside or marine leg. The whole building is made fire-proof on the exterior by means of a covering of corrugated iron. This warehouse has three sets of elevator legs—one to elevate from vessels, one to distribute, and one to discharge.

The New York Central or city elevator, (recently burned down,) was built of brick, the foundation being of the usual pile construction. It was divided into three compartments by brick walls, raised as high as the bins. These brick walls formed a fire-proof casing for the bins, as it were, which were composed of plank precisely as in the before-described Sternberg warehouse. The roof and framing of the upmost story rests upon the outside brick walls, and not, as in the case of the Sternberg, upon the bins themselves. The storage capacity of this building was 450,000 bushels, with a transfer capacity of 4000 bushels per hour. There were attached to this elevator seven sets of legs, of which one was used for raising grain from vessels, two for filling house, one to load cars, and three for emptying house.

The Reed Elevator, with a capacity of 200,000 bushels, was, at the time it was built, (1862,) considered the most complete elevator in all its appointments in Buffalo, and cost about $40,000. The first story is brick, resting upon piles, and the bins, 50 feet high, are made in the usual way of plank laid flatwise. This building is made externally fire-proof, by having the tower portion covered with corrugated iron, the sides and roofs being slated. In connexion with the Reed Elevator is a grain dryer, known as Marsh's patent. In general, the operation of this dryer is as follows: The damaged grain is elevated by the marine leg, and discharged through a spout in such a manner that it will spread over a metal surface perforated by very fine holes. The grain thus fed at one end is stirred and worked across the metal surface by means of a mechanical rake. Under that half of the surface which is towards the receiving end, a current of *hot* air is forced, and under the other half, a current of *cold* air, which cools the heated grain. It is then in a condition for storing, and is spouted into a receiving hopper in the interior of the building, the house leg raising it for distribution to the various bins.

This dryer has a drying surface of a little over 800 square feet, and will dry a maximum of five hundred bushels of wet grain per hour.

The small elevator of the Erie Railway Co., at Dunkirk, has a capacity of 24,000 bushels, and is situated in the middle of a pier jutting out into the harbor about 500 feet. The pier room on either side of this warehouse is shedded over for the reception of eastward and westward bound freights. The railway tracks run the whole length of the pier and through the elevator.

The method here employed to weigh grain is different from that in use at any of the other elevators. In addition to the arrangements in the tower for weighing the grain received, another is used to weigh the grain shipped in each car. This consists of a hopper, with scale attached, placed on a small truck, and is run under any bin that is to be emptied. As fast as a hopperful is weighed, it is spouted off into the car placed to receive it. This building is not protected against external fire, the bins and tower being merely sided up and down, and the cracks battened.

The Union Railroad Elevator, at Cleveland, differs considerably in its arrangements from any of those previously mentioned, inasmuch as it either receives from cars or boats, or distributes to cars or boats. The ground plan is 114 feet by 65 feet, with a boiler room of 33 by 35, built alongside. The cars are weighed in the building itself, on long platform scales.

The Michigan Central and North Indiana Railroad has three elevators at Toledo, with a total capacity of 1,250,000 bushels, but inadequacy of foundation will never allow of their being entirely filled. These warehouses elevate from cars alone, and transfer to boats by means of spouts.

By far the largest elevators yet built are those of Chicago, which, like those of Toledo, receive alone from cars, transferring to boats for eastern ports; among these the Sturgers & Buckingham is one of the finest. This building covers an area of 200 by 100 feet, and has a capacity to store 700,000 bushels of grain. The foundation consists of piles, protected around the whole periphery by a substantial cribbing. This elevator, like all others in Chicago, is cased with brick, slate not being in so much favor as a fire-proof protection. The Flint & Thomson elevator at this place, has a capacity of about 1,250,000 bushels, which is the largest grain warehouse ever constructed.

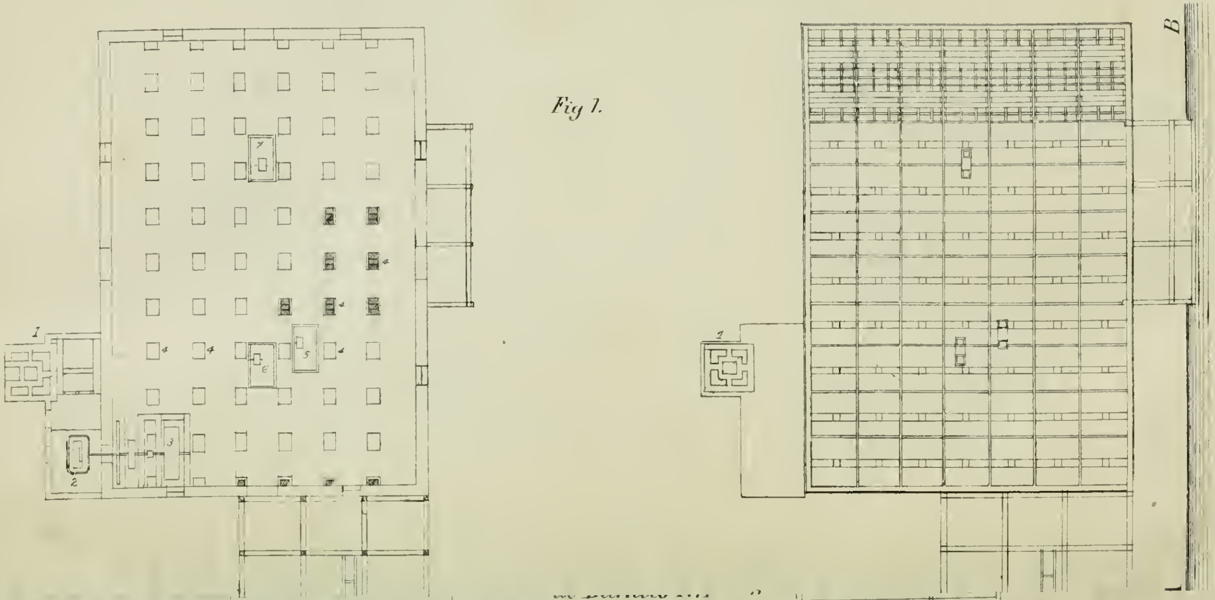
The accompanying plates represent a recently completed elevator, at Buffalo, called the "Richmond Elevator," and shows the whole internal working and arrangement of machinery.

Plate I, Fig. 1, shows the location upon the dock, and also the plans of the foundations and bins. The boiler is in a small building adjoining the warehouse, the engine being inside the main building, on the first floor, as shown. There are seventy-two bins, the three interior elevator legs and belting from the fly-wheel shaft taking up the space of five bins. These bins are 50 feet high, and 10 feet from centre to centre.

Fig. 3 shows a plan of the spouting conducting the grain from the house legs to the several bins.

Fig. 2 shows, on the left side, a section through centre of building and tower, and on the right side an interior view, with the tower

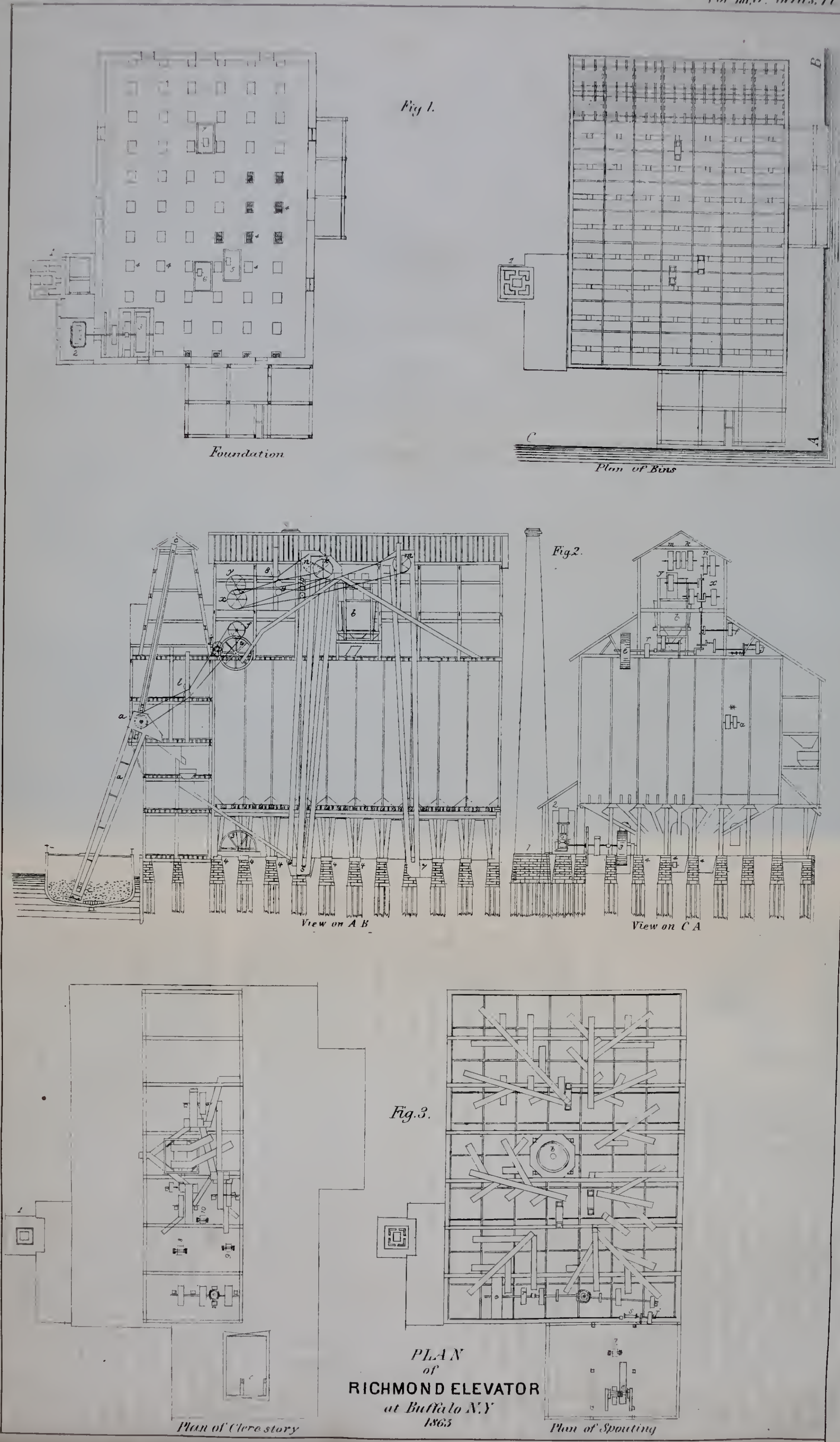
Fig 1.



Plan of Clere story

1865

Plan of Spouting



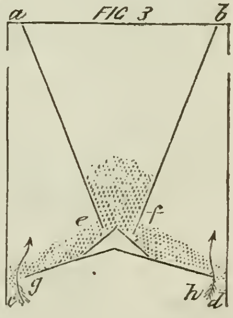
PLAN
of
RICHMOND ELEVATOR
at Buffalo N.Y.
1865

portion removed. A vessel is represented alongside of the dock being unloaded, the marine-leg having been lowered into its position by means of the block and tackle, which is seen running up to the top of the tower. The slack, which would otherwise be in the band that drives the head pulley in the marine leg, is taken up by the tension pulleys, as shown at Fig. 2. These tension pulleys are nothing more than small band wheels, revolving in a frame, which frame slides up and down between two guide posts. This frame is weighted sufficiently to always bear down upon the driving belt, no matter what the position of the marine leg, and thus produces a proper amount of friction for the belt to accomplish its purpose. The weighing hopper is shown in the tower, also the spout, directing the grain, when weighed, to the foot of one of the house legs, which elevate it to the top of the building for distribution.

The interior view, on the right of the plate, shows the construction at that part of the building where the grain is merely transferred to boats. It is fitted up with a receiving and weighing hopper, the former being filled by a spout from one of the house legs. When it is desired to transfer grain that is in store, it is necessary to discharge from the bins that are to be emptied into one of the hoppers that a house leg connects with, and then elevate to the top of the building, and spout into the receiving hopper of the transfer portion. [The various portions of the machinery, &c., in so far as is necessary to identify them, are marked the same upon all the plates.] This elevator was built by Mr. George Clark, of Buffalo, and has in connexion with it very perfect arrangements for cleaning, drying, and cooling grain, all of which were designed by Mr. Clark, and they are as perfect in their operation as is possible to conceive of. The *cleaner* is shown upon the preceding plates, marked *b*, situated about the centre of the building, and above the bins.

The whole apparatus is enclosed in a large wooden cylinder, of which the figure represents a section through the center. The accompanying cut, Fig. 3, will show the principle of its construction. *a b c d* represents a vertical section of the cylinder, having a hopper, *a b e f*, constructed within it. The grain to be cleaned is spouted from one of the house legs, directly into this hopper. Below the mouth of hopper, as shown, is a small flattened cone, which is so attached as to regulate, automatically, the amount of uncleaned grain fed to the spreading cone *g h*. Upon the top of the cylinder, and on either side, are two fan-blowers, which suck the dust and chaff up in the direction of the arrows, the grain thus winnowed dropping into the spouts beneath, which direct it to the proper bin for storage. The chaff is carried off by spouts attached to the sides of the cylinder, to what may be called a waste bin.

FIG. 3



The *dryer* and *cooler* is in a separate building adjoining the eleva-

tor, of which the subjoined cut, Fig. 4, represents the foundation, in which *a* is the furnace room; *b*, smoke stack; *c c c*, flues; *j*, drying kiln; *h*, hot air pressure chamber; *i*, hot air exhaust chamber; *g*, machinery room; *e* and *e′* are cool air chambers; *d* is the cooler.

FIG 4.

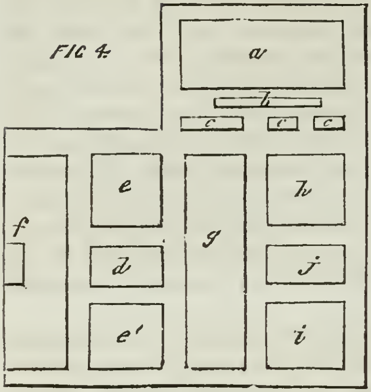


Fig. 5 shows an end elevation, in which C D is the drying bin; *a b* is an elevator leg to convey dried grain to cooler; the arrows indicate the operation. The grain is spouted into the top of the dryer from one of the house legs. This dryer is a fire-proof box, as it were, filled with inverted triangular troughs of perforated sheet iron, among which the wetted grain gradually works its way by its own weight. These troughs are sealed up at alternate ends, so that the hot air forced into the dryer through the troughs can only find vent through

FIG 5

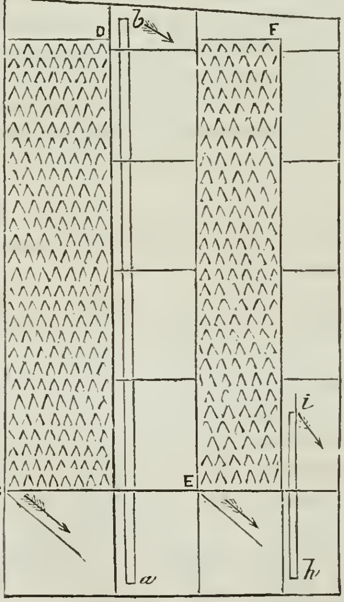
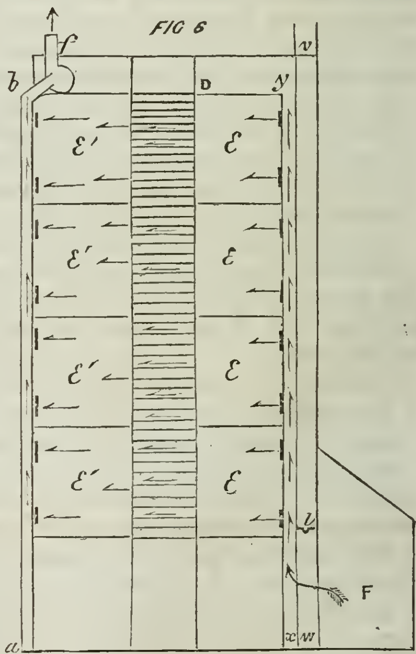


FIG 6



the perforations, and thus insures the whole of the grain becoming thoroughly dried. A spout directs the dried grain to the foot of the elevator leg *a*, when it is again elevated and discharged into the cooler F E, where it goes through a similar process, only being supplied with a cold blast

instead of a hot one, and is directed to the base of the elevator leg *h*, and elevated to a sufficient height to be spouted into the main building, when the house legs elevate it finally for stowing. This is the general idea of the process, but the exact method may be perhaps understood by referring to Fig. 6. F is the furnace room; *w v* is the chimney from which the heat may be directed into the heater *x y*, by means of the damper at *l;* E E, &c., fire-proof hot air chambers, the outside walls of brick, the inner partitions of cast iron; C D is the drying kiln, corresponding to C D in Fig. 5, filled with the triangular troughs, troughs closed at one end; an open and a closed end are made to alternate with each other, so that the heat may be retained as long as possible before passing off; E′ E′, &c., are the hot air exhaust chambers shown in Fig. 4; *a b* is an exhaust flue, the draught being made by the suction fan at *f*.

In the hot air flue *x y* are registers, shown by the arrows; arrows also show the passage of the hot air from the furnace through the grain, and out through the exhaust flue. The cooling part of the operation is exactly similar, the cold air being sucked by fans through apertures in the walls, which apertures take the place of the registers of the hot air flues. The quantity of hot air admitted is ingeniously arranged by an automatic contrivance depending upon the contraction and elongation of an iron lever connected with the registers. This bar, in its contraction and expansion, opens or closes the registers, and thus admits a perfectly equable current of hot air. The whole arrangement reflects a great credit upon its inventor, Mr. Clark.

This dryer and cooler will dry and cool four thousand bushels of wet corn per hour, or two thousand bushels of new corn. It has a heating surface of sixteen thousand square feet, a strong contrast to the Marsh dryer, which has a little over eight hundred square feet. The price for drying and cooling new corn was, in 1864, four cents per bushel, and for wet corn, one and three-quarter cents, which were very remunerative rates at that time. The cost of this addition, all complete, to the Richmond Elevator, was thirty thousand dollars. During the same season, 1864, the price for elevating grain at Buffalo, was one and one-half cents per bushel, and one and three-quarter cents for storage after the first five days.

(To be continued.)

For the Journal of the Franklin Institute.

Anchors and Chains of Sail and Steam Vessels.—Their weight, dimensions, and length. By CHAS. H. HASWELL, Engineer, New York, U. S.

Read before the Institution of Naval Architects, London, March 23, 1866.

Within a comparatively brief period the chain cable has been introduced in marine navigation *in lieu* of the hemp cable long in use antecedent thereto, and scarcely had their relative merits and capacities been developed, before two novel elements in marine navigation, affecting the weights and dimensions of both anchors and chains, have been presented, in clipper ships and steam vessels.

In England, the regulations and the requirements of the underwriters are such as very satisfactorily to provide for the proper equipment and fitting of a vessel in her requirements of "ground tackle," as it is termed, so far as her security at anchor is concerned.

The question, however, very naturally arises, Upon what deductions are these regulations based? Are they unnecessarily onerous in some points, and insufficiently provident in others? Are the varying elements of full-modeled and clipper builds, full and light-rigged vessels, or sea and river steam vessels, fully considered? If not, the requirements for safety, the economy of cost of equipment, the unnecessary burthening of a vessel, are all involved in these questions, and, in my opinion, each are of sufficient interest to justify an invitation of the attention of this body to the subject submitted.

In the merchant service of this country there are but few restrictions put upon the character and extent of either the equipment or fitting of a vessel, the matter being controlled by the builder or owner of the vessel, under the guidance of their knowledge, or views of their interest, on the one hand, and by the opinion of the underwriters upon the other.

In the naval service, however, rules for the determination of the weights of anchors, and the diameters of their chains, have been adopted, together with regulations as to the number of anchors and kedges and the lengths of cables.

The basis of the rule for the weight of anchors is the width of beam of a vessel squared, to which is assigned a unit, expressing the relative resistance of differing rates of vessels, in several classes, in their spars and rigging, and as the element of tonnage, under the old and now happily repealed United States law, is used as expressing the volume of a vessel, the rule is complicated, and as the units given are confined to naval vessels alone, the rule is too partial for general utility. I purpose, therefore, to submit to your consideration a rule, similarly based, for vessels of the merchant service, introducing the length of a vessel *in lieu* of tonnage computation, under an abrogated law, and thus rendering the application of it more *facile*, added to which, under existing rules of underwriters, and the various tables of weights of anchors, chains, &c., &c., published by the makers and venders of them, their weight is based upon the tonnage of a vessel without any reference to existing differences in model or rig, and, as the computations for tonnage vary in different countries, the rule is partial in the cases to which it applies, and restricted in its operation, without the intervention of the necessary reduction by computation.

As regards the propriety of tonnage or *volume* of hulls, in any manner being made the sole basis of assignment of the weight of an anchor, &c., I submit the following instances in illustration of its impracticability, viz: A full-built and full-rigged sailing vessel; a full-rigged clipper; a full or light-rigged side-wheel or propeller steamer; and a three masted schooner, all of which, if being of like tonnage, would have differing requirements of anchors and chains, and yet, under the general rule based upon tonnage, they would be fitted with

anchors of like weights, unless the differences should be estimated by the individual controlling the matter, in accordance with his particular views or interest, and, of course, subjected to the accident of his ability or truthfulness to discharge the duty.

As regards steamers, the general rule adopted, even by the regulations of Lloyd's, is that of assigning the weight of anchors at two-thirds that of a sailing vessel of like tonnage, without any reference to their being side-wheels or propellers, or to the character or extent of their rig.

In the following table the varying elements of construction, rig, and volume are considered, and an unit of computation assigned for each:

TABLE *whereby to determine the Weight of the Anchors, (exclusive of their stocks,) and also the number of anchors and kedges and lengths of chains for a vessel of a given class and rate.*

CLASS OF VESSELS.	Multipliers.	Number assigned.			L'gth of chains in fathoms.	
		Bowers.	Stream.	Kedges.	Bowers.	Stream.
SAILING.						
Ship, full built, length exceeding 180 feet.	3·	3	2	2	300	105
“ “ “ 150	2·9	3	1	2	300	90
“ “ “ 120	2 75	3	1	2	270	90
“ half clipper, “ 180	2·8	3	2	2	300	105
“ “ “ 155	2·7	3	1	2	300	90
“ “ “ 130	2·6	3	1	2	270	90
“ clipper, “ 220	2·8	3	2	2	300	105
“ “ “ 185	2·7	8	1	2	300	90
“ “ “ 150	2·6	3	1	2	270	90
Bark, full built, “ 130	2·75	3	1	2	270	90
“ “ “ 110	2·6	3	1	2	210	75
“ “ “ 90	2·4	3	1	2	210	75
“ half clipper, “ 130	2·65	3	1	2	270	90
“ “ “ 100	2·35	3	1	2	210	75
“ clipper, “ 140	2·6	3	1	2	270	90
“ “ “ 110	2·35	3	1	2	240	75
Brig or brigantine, full built, “ 100	2·4	3	1	2	240	75
“ “ “ 75	2·3	3	1	2	210	75
“ half clipper, “ 110	2 2	3	1	2	240	75
“ “ “ 85	2·1	3	1	2	210	75
“ clipper, “ 120	2·2	3	1	2	240	75
“ “ “ 90	2·	3	1	2	210	75
Schooner or sloop, full built, “ 125	2·	3	1	2	240	75
“ “ “ 100	1·8	3	1	2	210	75
“ “ “ 75	1·5	2	1	1	180	60
“ “ “ 50	1·25	2	1	1	150	60
“ half clipper, “ 125	1·8	3	1	2	240	75
“ “ “ 100	1·6	3	1	2	210	75
“ “ “ 75	1·4	2	1	1	180	60
“ “ “ 50	1·2	2	1	1	135	60
“ clipper, “ 140	1·75	3	1	2	240	75
“ “ “ 110	1·5	3	1	2	210	75
“ “ “ 80	1·25	2	1	1	180	60
“ “ “ 50	1·15	2	1	1	135	60
Boats..	1·2	1	...	...	25	...

TABLE, (*continued.*)

STEAMERS.						
Propeller, ship or bark, l'th excd'g, 325 feet.	2·8 / 2·6	3	1	2	300	105
" " " 300	2·75 / 2·55	3	1	2	300	105
" " " 275	2·7 / 2·5	3	1	2	300	105
" " " 250	2·6 / 2·4	3	1	2	300	105
" brig, " 250	2·5 / 2·3	3	1	2	300	105
" " " 200	2·35 / 2·2	3	1	2	270	90
" brigantine, " 225	2·25 / 2·05	3	1	2	270	90
" " " 175	2·1 / 1·9	3	1	2	270	90
" schooner, " 225	1·9 / 1·7	3	1	2	240	75
" " " 175	1·7 / 1·5	2	1	2	210	75
" " " 125	1·5 / 1 3	2	1	1	180	60
" tug boats, " 125	1·3 / 1·1	2	1	1	180	60
" " " 75	1·2 / 1·	1	1	1	120	45
" without any rig, with upper deck cabins fore and aft...........	2·1 / 1·9	2	1	1	180 / 120	60 / 45
" with deck cabins only.........	1·8 / 1·6	2	1	1	120 / 105	60 / 45
Sidewh'ls, ship or bark, l'gth exc'dg 300	2·8 / 2·6	3	1	2	300	105
" " " 275	2·75 / 2·55	3	1	2	300	105
" " " 250	2·62 / 2·4	3	1	2	300	105
" brig, " 250	2·55 / 2·35	3	1	2	300	105
" " " 200	2·4 / 2·2	3	1	2	270	90
" brigantine, " 225	2·3 / 2·1	3	1	2	270	90
" " " 175	2·15 / 2·	3	1	2	270	90
" schooner, " 225	1·95 / 1·75	3	1	2	240	75
" " " 175	1·75 / 1·55	2	1	2	210	75
" " " 125	1·55 / 1·3	2	1	1	180	60
" tug boats, " 125	1·45 / 1·25	2	1	1	180	60
" " " 75	1·35 / 1·15	1	1	1	120	45
" without any rig, with upper deck cabins..............................	2·3 / 2·	2	1	1	180 / 120	60 / 45
" with deck cabins only.........	2· / 1·8	2	1	1	120 / 105	45 / 45

Bower anchors should be alike in weight. For the convenience, however, of light-handed crews, it is customary to make a very material difference between them, which is a very grave error; for if the best or heaviest should foul, or be lost, the second, or "working anchor," as it is termed, is altogether insufficient to hold the vessel when more than ordinary security is required.

If, however, the rule of like weights is departed from, it should not exceed the proportion of 10 per cent. added to the standard weight for the best bower, and a like deduction from the standard for the second best bower.

The weights of all anchors and kedges are given exclusive of the weights of the stocks.

The weight of a stock is about one-fourth of that of its attached anchor.

Stream anchors should be one-fourth the weight of the bower.

Kedges, when two are used, should be one-sixth and one-tenth the weight of the bower, and when one is used, one-eighth of that weight.

The application of the preceding table is as follows:

Multiply the square of the extreme breadth of the vessel by the unit given in the column of multipliers, and the product will give the weight of the anchor in pounds.

To determine the diameter of a chain cable corresponding to an anchor of a given weight, cut off the two right-hand figures of the number expressing the anchor's weight in pounds, and multiply the square root of the remainder by 4, deduct 3 from the result when the anchor's weight is of and over 8000 lbs., 2 when it is between 7000 and 8000, and 1 when it is of 7000 or more than 4000, and it will give the diameter of chain in *sixteenths* of inches.

For the Journal of the Franklin Institute.

Cambered Bridge vs. *The Arch.* By De Volson Wood, Prof. C. E., University of Michigan.

In the last May number of the *Journal*, page 291, I find the following remark: "When camber is properly constructed in a bridge, the bottom chords are not strained by tension, until the deflection of the truss is so great as to pass the horizontal chord line. *Until* then the whole truss acts like a flat arch, and consequently, when the camber is considerable, no deduction for loss of strength by area cut away need be provided for, as would be necessary for a straight beam, when deflection to the slightest amount would call upon the bottom chord to resist tension."

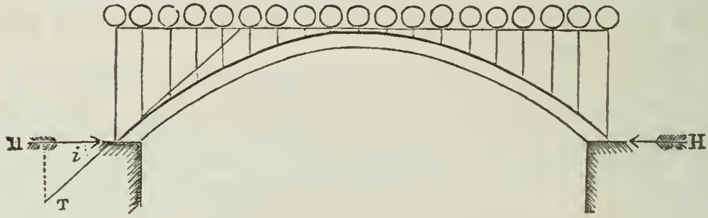
If I correctly understand the writer in the above statement, I think it involves an erroneous principle. The idea seems to be, that in a flat arch there is no tendency to tension on the lower side. It is true, when the arch is composed of disconnected parts, as voussoirs, it resists only compressive strains, but in this case, the thrust of the arch must be resisted by a force at the abutment. This force may be the

pressure of the abutment, or of the earth, or friction on the abutment, or a horizontal tie, or by some of these combined. But in the cambered bridge—the case discussed by the writer—the truss simply *rests* on the abutments. For such a case, whether it be a cambered bridge, a trussed arch, a curved beam, or a roof shaped truss, when acted on by vertical forces only, I venture the broad statement that, *when the upper part is compressed, the lower part is* EXTENDED.

I will not at this time enter into an analysis, but will make a few statements, the truths of which are so evident that I trust they will carry conviction.

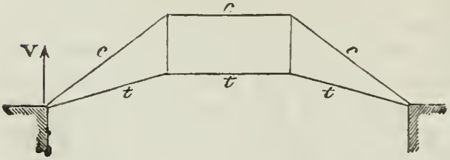
If an arch could be so loaded that it would be a curve of equilibrium, *i. e.*, so that the resultant of the forces at any point would be in the direction of the tangent to the intrados at that point, and the same curve be vertical at the abutments, then there would be only compressive strains; such might be the case with normally pressed arcs, or so made by some peculiar law of loading. It is, however, more ideal than real.

Fig. 1



If the arch be parabolic and uniformly loaded over the span, it will be a curve of equilibrium. But as it is not vertical at the abutment, it will tend to slip outward. If T be the thrust at the abutment i the angle which the tangent to the curve makes with the horizontal, and H the horizontal component of the thrust, we have $H = T \cos. i$, which must be resisted by a tie or friction, or some other force. If there be no extraneous force, then, when it slides out, the crown will be depressed, and tend to break by being compressed on the upper side *and extended on the lower.*

Fig. 2



Take the simple case shown in Fig. 2. If the lower end pieces are subjected to tension, then must the lower middle one also be subjected to tension. No bridge builder would venture to cut away any of the lower timbers in this case.

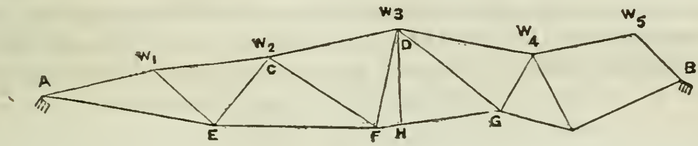
I trust that these examples are sufficient to illustrate the correct principles.

Formulas for Obtaining the Strains on the several parts of Girders and Roofs. By Alfred A. Langley, C. E.

From the Civil Engineer and Arch. Journal, May, 1866.

Let any triangular combination of bars, such as is shown in the annexed figure, be loaded with weights w_1, w_2, w_3, &c., at the point of junction of the intermediate and upper bars. Find the weight or reaction at the support A owing to these weights, which call R. Let S equal the strain on any of the lower bars in the direction of its

Fig. 1.



length, which strain we shall now proceed to find on the bar FG. Draw the line HD perpendicular to FG, and through the point D. Let the sum of the weights between D and the support A be called W, and let the horizontal distance of its centre of gravity from D be called g, also let d equal the horizontal distance between A and D. Then taking the moments about the point D, we have—

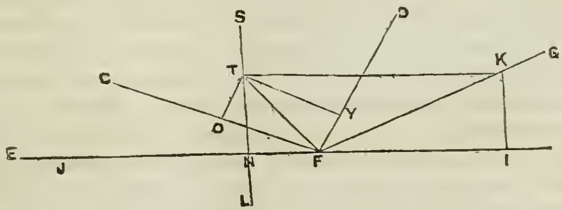
$$S = R \frac{d}{DH} - W \frac{g}{DH}.$$

By the above process the strains on each of the lower and upper bars may be obtained; the upper bars will be in compression, and the lower ones will be subject to a tensile strain.

Intermediate Bars.—There are four bars meeting at each side of the points E, F, G, &c., their directions are known, and after obtaining the strains on the two lower bars by the preceding formula, the forces acting on the remaining two intermediate bars can be calculated by properly resolving the forces so that they may be in equilibrium.

The forces can readily be arrived at by construction as follows: Let the inclination of the four bars meeting in F be shown in Fig. 2

Fig. 2.



by the lines EF, CF, DF, and GF. On the lower bars set off distances, FJ and FK, representing the strains on these bars. Produce the line of

the bar on which there is the greatest strain, which we will suppose to be JF. Draw a line from K perpendicular to EF, and intersecting it in I. Set off JN = FI. Draw LS through the point N, perpendicular to JF, and draw a line parallel to EI from K, intersecting LS in T; then will TF be the resultant of the forces acting on the intermediate bars. From T draw lines parallel to FD and FC, intersecting them in O and V; then will FO and FV represent the strains on FC and FD, respectively. When T lies between the intermediate bars, they will both be in compression, and, when between the lines of the intermediate bars produced below F, both in tension; but if the resultant is not in either position, then the bar nearest T will be in compression, and the other in tension. Let the strain on EF and FK = H and h respectively; also let the angles CFE, CFD, and DFG $= \alpha$, β, and φ, respectively, and the required strain on CF $= x$ and on DF $= y$; we can then at once write down.

$$x = \pm \mathrm{H} \frac{\sin.(\alpha + \beta)}{\sin.\ \beta} \pm h \frac{\sin.\ \varphi}{\sin.\ \beta}$$

$$y = \pm h \frac{\sin.(\varphi + \beta)}{\sin.\ \beta} \pm \mathrm{H} \frac{\sin.\ \alpha}{\sin.\ \beta}.$$

For the Journal of the Franklin Institute.

Comparison of the Actual and Effective Area of Exhaust Openings.

By Fred. J. Slade.

In investigating physical phenomena, by means of mathematics, or in making deductions from laws already determined, it is unsafe to proceed far without checking and verifying our results by direct appeal to experiment. This is the more essential as in the majority of cases a variety of causes are in operation at the same time, mutually modifying their effects.

Thus, in regard to the subject before us, it is easy when we know the area of an exhaust opening and the time during which it exists, to calculate the quantity of steam that will be discharged, and ascertain the resulting back pressure against the piston, if we suppose the steam simply to obey the law of velocity of fluids under a difference of pressure, and the cylinder to contain only its own volume of steam. But when we consider the effects of leaky valves, water remaining in the cylinder either to be evaporated or carried off as spray, and the friction of crooked pipes, all of which exert their influence in practice, we see the necessity of taking the direct testimony of the engine itself, which we can do by means of the indicator. With this object, the writer has selected promiscuously a number of diagrams from engines of which he had sufficient data for the purpose, and, calculating the theoretical discharge of steam during each tenth of the return stroke, will show how it compares with the apparent actual discharge as represented on the diagram. The method of calculation is simply as follows:

Let C = contents of space from the piston to the end of cylinder in cubic feet.

C_x = contents of space from the piston to the end of cylinder in cubic feet, after the former has moved through a distance x.

P = pressure above a vacuum in space C.

P_x = " " " " C_x.

(1.) Then $\dfrac{CP - C_x P_x}{\frac{P + P_x}{2}}$ = *apparent* actual discharge of steam in cubic feet at the mean pressure $\dfrac{P + P_x}{2}$.

Let A = smallest area of exhaust opening in square feet.

t_x = time, in seconds, occupied by the piston in reducing the contents of the cylinder from C to C_x.

p = external pressure in condenser or atmosphere.

c = cubic feet of steam of pressure $\dfrac{P + P_x}{2}$ equal to one pound.

(2.) Then $\sqrt{c\left(\dfrac{P + P_x}{2} - p\right)} \times 96 \times t_x . A$ = theoretical discharge of steam in time t_x, and (1) divided by (2) gives the relation between the actual area A, and the effective area under all modifying circumstances, which we will denote by R.

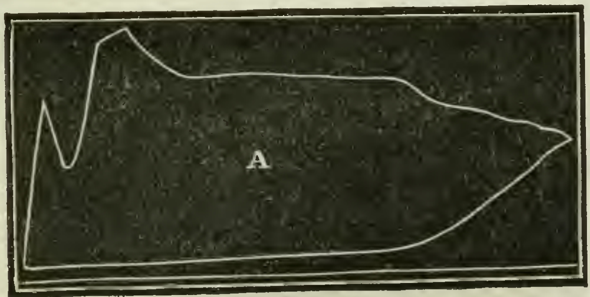


Diagram A is from a high pressure engine of 12 inches by 18 inches cylinder taking steam at 43 lbs. pressure during the whole stroke, making 95 revolutions and exhausting through 11 feet of 3 inch pipe and 5 elbows into a feed-water heater, thence through 32 feet of 3 inch pipe and 4 elbows into a large tank of about 150 times the capacity of the cylinder, and emerging from this near where it enters at the top through 100 feet more of 3 inch pipe and 14 elbows into the atmosphere. This is a case of considerable resistance from the tortuous line of exhaust piping, though it must have been somewhat relieved by the large tank acting as a temporary reservoir for the steam. The steam was quite wet, and, moreover, the exhaust pipe itself was the smallest part of the exhaust passage.

The results for this engine were as follows:

Tenths of stroke.	Area, square inches.	Time, t_x.	Apparent actual discharge, cubic feet.	R
1	3·80	·070	·387	·16
2	7·07	·032	·315	·18
3	7·07	·027	·217	·18
4	7·07	·021	·156	·18
5	7·07	·021	·125	·16
6	7·07	·021	·118	·16
7	7·07	·021	·130	·17
8	7·07	·022	·122	·17
9	7·07	·027	·119	·14
10	4·60	·062	·120	.10
Average				·16

The back pressure in the cylinder represents an apparent discharge of only ·16, that theoretically due to the area of opening. We say *apparent* discharge because the quantity of steam actually delivered must be greater from the causes before alluded to, but it is this apparent discharge that is of value practically as determining the amount of resistance to the piston.

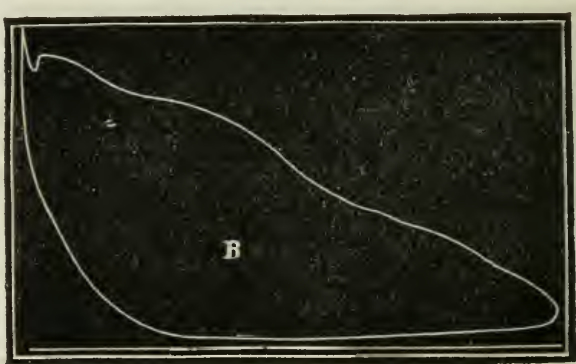


Diagram B was taken from locomotive No. 204, Erie Railway. Incidentally, we may remark, that locomotive diagrams are interesting from their rarity, and, indeed, it is believed that the series, of which this is one, taken by the writer, assisted by Mr. Phineas Barnes, Jr., in the summer of 1864, were the first ever obtained from a locomotive in this country.

In a locomotive we should expect better relative efficiency of exhaust area, since the whole of the passage is considerably larger than the one smallest part—the blast orifice—the exhaust pipe is very short

and the steam generally tolerably dry. The cylinders of this engine were "inside," and, therefore, kept warm by the smoke-box. The diameter of exhaust nozzle was $3\frac{1}{4}$ inches; steam ports, $15\frac{1}{2}$ inches by $1\frac{3}{4}$ inch; exhaust port, $15\frac{1}{2}$ inches by $2\frac{3}{4}$ inches; cylinder, 18 inches by 20 inches. At the time this card was taken the engine was making 160 revolutions per minute.

The results were as follows:

Inches of stroke.	Area of opening, square inches.	Time, t_x.	Apparent actual disch'ge, cubic feet.	R
$17\frac{2}{3}$—$19\frac{1}{2}$	4·14	·033	·51	·35
$19\frac{1}{2}$—20	8·3	·019	·731	·51
20 —18	8·3	·043	1·04	·40
18 —16	8·3	·019	·338	·37
16 —14	8·3	·015	·322	·45
14 —12	8·3	·013	·269	·43
12 —10	8·3	·0124	·312	·52
10 — 8	7·6	·0124	·294	·54
8 — 6	4·8	·013	·202	·52
6 — 5	1·7	·007	·025	·35
Average				·444

It will be noticed that the efficiency of opening increases toward the end of the stroke which may, perhaps, be best accounted for by the supposition that the evaporation and discharge of water from the cylinder reduces the apparent discharge at the first part of the stroke, though the actual discharge may be as large as at any other period.

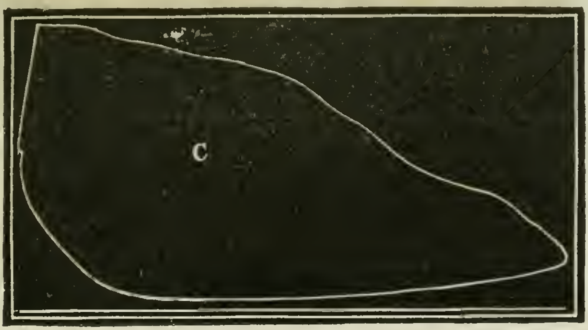


Diagram C is from engine No. 203, Erie Railway, the dimensions of which are: Cylinders, (inside,) 18 inches by 20 inches; steam ports, $15\frac{1}{2}$ inches by $1\frac{3}{8}$ inch; exhaust ports, $15\frac{1}{2}$ inches by $2\frac{3}{4}$ inches; exhaust nozzle, $2\frac{7}{8}$ inches diameter. The card was taken at a time when the engine was developing the large amount of 519 horse power, making 144 revolutions per minute; and we accordingly find a high back pressure against the piston, averaging, exclusive of compression, 10·5 lbs. above the atmosphere.

The efficiency of the exhaust opening was as follows:

Inches of stroke.	Area of opening, sq. inches.	Time, t_x.	Apparent actual discharge, cubic feet.	R
17·85 — 19·4	3 24	·025	·63	·564
19·4 — 20	6·49	·0255	·57	·32
20 — 18	6·49	·048	1·17	·38
18 — 16	6·49	·0206	·495	·415
16 — 14	6·49	·0165	·456	·50
14 — 12	6·49	·0143	·353	·46
12 — 10	6·49	·0136	·324	·46
10 — 8	6·49	·0136	·332	·475
8 — 6	4·75	·0143	·294	·56
Average..				·46

The results in this case differ but little from those from the preceding diagram.

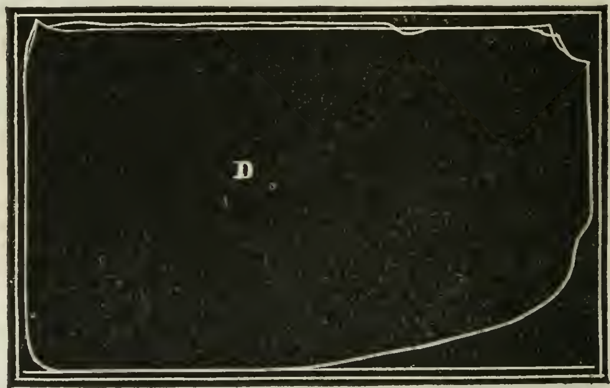
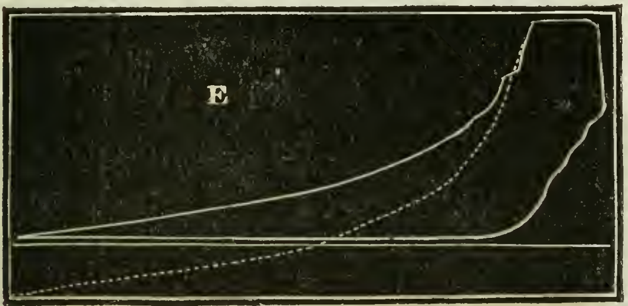


Diagram D, from engine No. 204, taken when the engine was starting its train, shows the rate of discharge of a large volume of steam at a moderate speed. In this case we have—

Inches of stroke.	Area of opening, sq. inches.	Time, t_x.	Apparent actual discharge, cubic feet.	R
20 — 18		·0783	2·56	·346
18 — 16	8·3	·0339	1·06	·415
16 — 14	8 3	·0273	·72	·43
14 — 12	8·3	·0235	·516	·44
12 — 10	8·3	·0225	·500	·59
10 — 8	8·3	·0225	·389	·88
Average..				·517

As the pressure in the last portion of the stroke calculated falls very near the atmosphere, the determination of R may be less accurate, as the least variation in measuring the diagram will make a considerable difference in its value. It will be observed that the value is unusually high. It should be borne in mind, however, that just at this time the other cylinder discharges its steam at a high pressure through a nozzle placed close beside the one through which this is exhausting, and this, acting as a steam jet, must tend to accelerate the flow of steam from the cylinder. When, as is sometimes the case, both cylinders exhaust through one nozzle, the discharge from one cylinder causes a considerable rise of back pressure in the other, amounting, when following full stroke, with the ordinary pressure of steam, to about 16 lbs. at the first opening of the opposite exhaust. For more ordinary points of cut-off, the back pressure is increased one or two pounds for about half the stroke.



Card E is from a stationary engine of novel but excellent construction. At the time of taking this diagram, however, the steam valve was leaking to an extent shown by the difference between the actual and theoretical lines, (the latter dotted,) which will account for the comparatively low value of R, since, as the exhaust pipe was short, straight, and larger than the greatest area of port, we should expect a good proportion of discharge per unit of area. The steam leaking into the cylinder during the exhaust would make the discharge appear smaller than it really was.

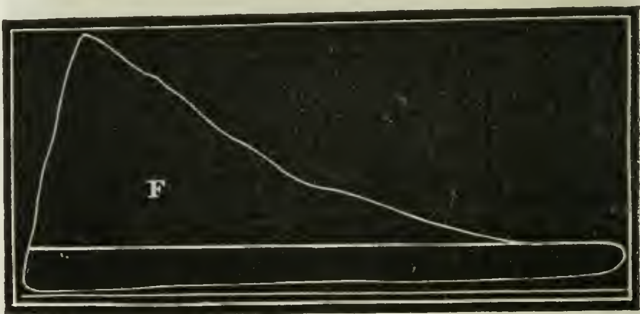
This, however, is a common case in practice, and on that account we give it a place.

The dimensions of the engine were: Cylinder, 26 inches by $30\frac{1}{8}$ inches; exhaust port, 24 inches by $1\frac{1}{2}$ inch. The amount of its opening, at each part of the stroke, which was the smallest part of the passage, is given in the table. Exhaust pipe, 33 feet long 7 inches diameter, with two elbows, both near the engine to conduct the steam into a feed heater, the remainder of the pipe being vertical.

At 48 revolutions the results were:

Inches of stroke.	Area of opening, sq inches.	Time, t_x.	Apparent actual discharge, cubic feet.	R
30—27	17·	·116	1·36	·20
27—24	28·	·052	·89	·205
24—21, 21—18, 18—15	31·5	1·345	2·8	·225
15—12	22·	·0444	·91	·33
12— 9	15·75	·0444	1 03	·57
9— 6	9·	·049	·78	·66
6— 3	3·	·057	·46	·54
Average				·353

The exhaust port opened at $1\frac{1}{4}$ inch before the end of the stroke, yet, on account of the leakage above referred to, the card shows nearly 2 per cent. more steam in the cylinder, at the end of the stroke, than at the time of opening of the valve.



Card F is from a low pressure stationary engine of 10 inches by 20 inches cylinder. The least opening was at the valve, the port being but 4·25 inches by ·68 inch = 2·89 square inches. The exhaust pipe was $2\frac{1}{2}$ inches diameter = 4·9 square inches area, 21 feet long, with four elbows. The valves were about as tight as usual in practice.

The line drawn below the diagram shows the vacuum in the condenser which was about $17\frac{1}{2}$ inches.

Another diagram taken from the same engine, exhausting into the atmosphere, through a pipe about twice as long, shows for R a higher value, viz: about $21\frac{1}{2}$.

The values obtained from the above diagrams will probably be lower than most persons would have anticipated. They are, however, no doubt, fair examples of ordinary practice, and are of interest on that account. They show clearly the importance of a short and free escape for the steam, and to many will be significant in relation to the water

condensed in the cylinder during the steam stroke to be discharged during the exhaust.

At 60 revolutions the results were:

Inches of stroke.	Area of opening, sq. inches.	Time t_x.	Apparent actual discharge, cubic feet.	R
19 — 20	·786	·0764	·074	·13
20 — 18	2·51	·116	·442	·18
18 — 16	2·89	·0485	·11	·12
16 — 14	2·89	·038	·10	·135
14 — 12	2·89	·0345	·099	·15
12 — 10	2 89	·033	·097	·158
10 — 8	2 89	·031	·108	·19
8 — 6	2·89	·032	·096	·17
6 — 4	2·88	·037	·106	·18
4 — 2	2·46	·041	·108	·23
2 — 0	1·62	·097	·073	·089
Average				·158

Dry Dock Iron Works, New York.

Portland Cement. By M. Leblanc.

From the London Civil Engineer and Architect's Journal, May, 1866.

Having been charged, since the commencement of the year 1860, with the construction of the floating basin of the port of Boulogne, we have employed in the masonry works of that basin many thousand tons of Portland cement. We have thus been able to make some observations, which have been checked by experience upon a large and a small scale, upon the qualities which ought to be sought for in this cement, and the best conditions for its employment. Our first researches had reference to the influence of the density of the cement upon its quality.

We took a certain volume, V, of light cement—a cement weighing about 1200 kilogrammes to the metre cube, the weight of it being ascertained by means of a box containing 100 litres, which was filled so as to avoid the pressing of the cement in the most perfect manner possible. We mixed this with two volumes, 2 V, of gravel, and then, after carefully stirring them, we made them into bricks of sixteen centimetres sectional area. We then weighed the same weight of the first choice heavy cement—a cement which weighed 1500 kilogrammes to the metre cube—whose volume v was rather less than the volume V, and we mixed this with 2 V of gravel likewise. We made this mixture into bricks, in the same manner as the first.

The resistance of an effort tearing the specimens asunder were:

	5 days.	15 days.	1 month.	3 months.
	Kilos.	Kilos.	Kilos.	Kilos.
Mortar of light cement v cement 2 v gravel	45	90	90	130
	65	70	90	130
	45	70	90	130
Average	51	76	90	130
Or in English pounds	112¼	167¼	198	286
	Kilos.	Kilos.	Kilos.	Kilos.
Mortar of heavy cement *v* cement + 2 v gravel	65	130	130	190
	85	130	150	190
	85	130	170	210
Average	78	·130	150	196
Or in English pounds	173¾	286	330	432¼

Thus proving the incontestable superiority of the heavier cements.

We asked M. Hervé Mangon to analyze these cements at the School of the Ponts et Chaussées, and he found they were of the following composition:

	Light cement.	Heavy cement.
Silica	26·30	24·45
Alumina and peroxide of iron	8·75	8·70
Lime	62·35	65·60
Sulphuric acid	0·35	0·45
Water and loss	2·25	0·80
	100·00	100·00

"These analyses prove distinctly," he further wrote, "that the second sample alone approached the true type of Portland cement, while the composition of the first sample was much nearer the composition of the cements which have a rapid setting, such as the Roman cements of Pouilly, Vassy, &c." M. Hervé Mangon then dissolved and shook up, in a cold state, two grammes of each sample in half a litre of water, containing 10 grammes of the nitrate of ammonia. After a contact of twenty hours he filtered the liquid, and found in the residue of the clear liquid: Lime dissolved, 0·825 in sample No. 1; 0·505 in ditto No. 2. Thus the product of this comparatively feeble dissolvent was less in the same proportion as the quality of the cement was better. M. Hervé Mangon terminated his letter in these words: "I cannot take upon myself to affirm that the manufacturers may not succeed in making a cement that should possess the bulk of the properties of Portland cement, and yet should be of a light specific gravity. Many trials are being made with that object. Some of these have yielded curious results; but this is certain, in my opinion at least, that in the existing state of the manufacture of cements it is impossible to unite,

in the same product, the lightness of the material with the precious qualities of the true Portland cement. I think, then, that it would be advisable to forbid the use of light Portland cement in all government works until new experiments, continued over long periods of time, should allow of this rule being set aside, which, I may add, is dictated by the most simple rules of common sense."

The actual inferiority of the light Portland cements, compared with the heavier varieties, being peremptorily proved by the facts above recorded, the administration would have the greatest possible interest in substituting, in the specifications that it issues, the dosing by weight to the dosing according to volume. It would thus relieve the contractors from any question of the density of the compound, and these men exercise the most regretable pressure upon the manufacturers, in order to obtain the lightest cements possible. It would, at the same time, render frauds more difficult, if not impossible, without the connivance of the agents charged with the superintendence. Now-a-days, as M. Hervé Mangon justly remarks, these weigh-bridges are instruments as simple as they are economical; the dosing of the mixture of cement and sand by weight has become as practical a method as the dosing by volume.

Here it is necessary to define what is meant by heavy cement. We shall hereafter call cement "heavy" when its weight, ascertained by the means of a box of the capacity of 100 litres, (that is a parallelopipedon of right angles of 0·50 m. long, by 0·50 m. broad, by 0·40 m. deep,) filled in a manner to avoid the pressure as much as possible, should never be less than 1350 kilogrammes in weight per metre cube, without the box. According to the mistaken notions of the marine engineers, (for a proof of which we may refer to the last specifications issued at Cherbourg,) we should say, perhaps, more exactly, a heavy cement is one whose specific gravity is superior to 1200 kilogrammes, when, for the purpose of ascertaining this gravity, the cement is poured in, without pressure, a measure of a litre, of a capacity of 1·10 on the side. For the purpose of ensuring greater exactness the litre ought to be filled twenty-five times in succession, with the same precautions, and the specific gravity will be ascertained from the results of the twenty-five weights thus formed.

It is to be observed, that the heavy cements generally set with less rapidity than the light cements. Thus, when such cements are employed, it is not advisable to attach much importance to the proof after the first forty-eight hours, which is, nevertheless, very convenient in general works, as it permits the stock to be renewed more readily. The proof after the lapse of five days can alone, with these heavy cements, be considered conclusive.

Mode of using Portland Cement Concrete under Water.—The concretes of Portland cement that are immersed in water suffer an energetic washing, which is to be accounted for by the fact that every piece of stone that comes in contact with the water is immediately deprived of the mortar which surrounds it; it does not, in fact, retain a trace of this mortar. Portland cement mortar is not rich and soapy,

in the style of the lime mortars, properly so-called. It does not stick to the trowel, but it is like pounded glass that is moistened, so bad an aspect does it present when it is rather stiff. Treated with sea-water, this mortar separates in three parts or strata. The upper stratum, A, is only a simple lime water; it does not set, remains soapy, unless it is dried. The middle part, B, acts as would a mortar that is of the kind known as "thin;" whilst the residue, C, appears alone to preserve some qualities of the mortar; but composed as it is of the heaviest grains, which are also the best burnt portions of the cement, it does not set with anything like rapidity. It is, moreover, diminished in strength by the mixture of a great part of the gravel, which enters into the composition of the mortar, which falls with it into the intervals which are left between the stones. Indeed, the density of the Portland cement is much nearer that of gravel than that of lime. It would appear then that the tendency of the elements of the mortar to separate would be less in the case of Portland cement mortars than it would be in those made of ordinary lime. But there is not the same adhesion in the grain of Portland cement to the materials with which it is mixed. Moreover, the cements that are met with in commerce do not weigh more than 1200 kilogrammes, when not pressed, and measured in a box containing 100 litres. The best gravel from the shore of Boulogne, measured in the same way, weighs as follows: 1 degree, when very dry, nearly 1700 kilogrammes; 2 degrees, when moist, nearly 1500 kilogrammes. Adopting this last figure, the density of the gravel would only be 25 per cent. greater than that of light Portland cement. But in salt water this difference between the densities of the cement and the gravel becomes notably exaggerated; for the effective weights in salt water become 200 and 500 kilogrammes, that is to say, that after the immersion the weight of the gravel would be found to be more than double that of the cement. It is this fact that may account for the ready separation of the elements that enter into the composition of the mortars that takes place in water.

M. Hervé Mangon has kindly repeated this experiment of washing, with pure cement. The cement that he operated upon presented the following composition:

	At moment of arrival.	Supposed deprived of the water.
Silica	25·60	26·61
Alumina and peroxide of iron	8·95	9·30
Lime	61·35	63·77
Magnesia	0·30	0·32
Water, carbonic acid, and matters not dosed	3 80	....
	100·00	100·00

It weighed 1440 grammes when it had been sifted, and it left, in the course of that operation, the following results:

Grains of $1\frac{1}{2}$ millimetre diameter	0·70
Grains varying from $1\frac{1}{2}$ to 1 millimetre diameter	0·70
Grains varying from 1 to $\frac{1}{2}$ millimetre diameter	0·40
Grains stopped by a sieve 36 meshes to the centimetre	28·20
Powder passing through a sieve 36 meshes to the centimetre	70·63
	100·00

The cement in its natural state, and mixed with the ordinary precautions, sets immediately under water. The parts that were extremely fine also set with equal success. The grains that were kept back by the sieve did not work up well, and they retained the appearance of sand; but with time, and even under water, this product set, and acquired a considerable degree of hardness. Thus the cement fulfilled all the conditions that were required, either as regards the chemical composition, the burning, the density, or the degree of pulverization. M. Hervé Mangon then dissolved in ten litres of water 800 grammes of this cement; he shook it, and then he poured off the water that had been allowed to clear itself. Lastly, he poured the cement thus washed into a smaller vase, where it divided itself into three layers, which presented the following differences, according to the chemical analysis:

	A.	B.	C.
Silica	7·15	10·20	22·30
Alumina and peroxide of iron	5·30	3·00	4·30
Lime	18·80	25·60	48·00
Magnesia	2·00	1·00	0·30
Water, carbonic acid, and matters not dosed, traces of the chlorides and sulphides	66·75	59·40	25·10
	100·00	100·00	100·00

Or. supposing these mortars to be deprived of the water and the carbonic acid that they contained, their composition would become—

	A.	B.	C.
Silica	21·5	25·2	29·7
Alumina and peroxide of iron	15·9	9·3	5·7
Lime	56·6	63·1	64·1
Magnesia	6·0	2·4	0·5
	100·0	100·0	100·0

The layer A was, in fact, a pure lime water; the lime was in part replaced with magnesia, which, being more voluminous than it was, opposed everything like a cohesion of the product. The layer B having been thinned by the mixture of a small portion of the cream of lime, was principally distinguished from the layer C by the differences

3 *

in the physical states of the layers. The layer C alone set in a satisfactory manner. In this case, again, the chemical analysis explained sufficiently the facts that had been experimentally observed. It must, however, be said that, in the opinion of M. Hervé Mangon, there does not exist, in the actual state of the fabrication of cements, a product of that nature which would resist such an energetic washing, particularly in sea-water.

This being settled, let us examine the conditions of the laying of the beton on the level of the water and under the water.

Case the first.—The ordinary practice—that consists in laying the fresh concrete a little behind the mass already in place, and then compressing it by rammers, so as to cause the wet concrete to swell and advance forward, while it always presents the same surface to the part in advance—is not possible with the Portland cement; the mortar is not sufficiently stiff, it is not soapy enough for that. The long slidings, which are occasioned by the widening of the mass that is spread out, and which is flattened in laying, causes the beton made with lime to advance slowly, and it is accompanied with an insensible degree of washing. These slidings do not take place with Portland cement, generally speaking. It is almost impossible to keep up a gentle slope with this description of beton. Now, when the slopes are very steep, the stones detach themselves and roll down, and thus the washing is produced. In this matter there may be observed in the whole height of the mass (but particularly about the level of the surface, where the action of the waves is most distinctly felt,) through the stones that are washed clear of the mortar, caverns imperfectly filled with gravel and the coarser grains of the cement, which constitute a mortar that is very thin, that covers the rest of the cement mixed up with a cream of that material, more or less mingled with the cement. Above the water the concrete is excellent.

Let us now consider the case wherein the concrete is executed under water, by means of boxes of a capacity which, as will be seen hereafter, it is advantageous to make as large as possible. The heaps of concrete are disposed one by the side of the other, but which have necessarily their slopes very steep, for the reasons before enumerated. In each heap the heart alone can be very sound, so that, if the position should contain any springs, it is tolerably certain that they will appear upon the surface of the layer of concrete when the excavation of the interior shall be laid dry; the springs will, in fact, follow the lines of the washed stones. It is true that these effects may be produced with lime mortars; but we believe we may affirm, without fear of being contradicted by fact, that they are much more serious with the beton made with Portland cement. The layers of mortar made of lime flatten more; we have in their case to deal with a complete layer, not with heaps that are juxtaposed. But, laid dry, the concrete made with Portland cement reassumes all its advantages over the concrete made with lime. Thus we have often noticed that a spring from below has forced a passage through the concrete made with Portland cement, like a hole pierced by a ball; the water had passed through, but the concrete only allowed its passage through the passage that

was strictly necessary. All around the hole, from the top to the bottom of the spring, the cement mortar retained its goodness. The concrete was pierced like a chimney whose diameter was reduced to just the dimensions that are absolutely necessary.

In the same manner water runs over fresh concrete without any serious consequences, except in the case of great speeds and great falls. To fill, by the means of the basin of the floating dock of Boulogne, that reserved portion, we had formed, with complete success, on one-half of the width of the passage, the first portion of the bed of concrete, the water being allowed to flow over the other part; afterwards we passed over the fresh bed of the current—the stream of water that was retained by a rim formed in the earth—and we filled the half that had remained empty, and thus on, successively passing the water over two sides.

We have thought that the stability—if we may express it thus—of the Portland cement mortar was in a great measure due to its great weight, which is more than half as much again as that of ordinary lime. In fine, if the concrete made with cement is with difficulty applied in water, it is possible to apply it dry in land charged with springs without inconvenience. If, however, it were absolutely necessary to apply it in water, we would recommend the use of machinery, in the style of "tremies," in preference to any others; for the two facts we have mentioned prove that a layer of Portland cement concrete may be spread under the water with the tremies with less alteration than a similar layer of lime mortar. We also would recommend that the concrete should be made with round stones, rather thin, with angular stones that are the result of the breaking of the ballast, for it is extremely important to facilitate the sliding of the materials one upon another, to make up for the want of an unctuous character in the Portland cement. We may here observe that a round pebble from our shore seemed to us as difficult to detach from a gangue of Portland cement mortar as a stone that was broken could be.

Mode of using Portland Cement Mortar in Masses of Masonry.—In the execution of masses of masonry, we think it is a good practice to employ the mortar of Portland cement sufficiently soft, so that it should more easily assist in the formation of beds that would form the seating of the stones, otherwise there is danger of the formation of many vacua under the masses; for the stiff Portland mortar acts as ordinary earth when it is worked with the trowel. Soft, however, it assumes a distinct character; it becomes more unctuous, and spreads more easily in the beds.

An excess of water, as might have been expected, has produced a weakening of the mortar; but if the stiff mortar yields resistances that are superior to those of fluid and very fluid mortars, it does not yield results that are comparable to those of the normal mortar, even when this is mixed with a great quantity of water.

Under stones used as ashlar and laid in elevation, the mortar of Portland cement which does not stick to the trowel (we may observe, moreover, that the ashlar stones of the floating basin at Boulogne, which are obtained from the carboniferous limestone of the valley of

Hercuse, in the neighborhood of Marquise, are of a marble that is very smooth,) tends, in throwing off the excess of its moisture, and in hardening, to allow the formation of hollow spaces by the effect of shrinkage under the beds, of which the existence is brought to light in times of rain. Thus, by reason of the porosity of the material, the rain-water, driven by the wind, can fill up the hollow spaces, which are made apparent, when the rain ceases, by the permeation of the moisture. The greatest care must, therefore, be taken to ensure the strict obtainment of the beds that should be perfectly resisting, and this would imply great skill on the part of the mason charged with the setting.

The following seems to us the best method to be observed in these cases: The workmen commence by spreading upon the beds of masonry a layer of mortar of two or three centimetres thick that is sufficiently stiff; they place about the angles of the face two wedges of a wood that is very tender, and these are driven in throughout their length; they equally wedge up with a piece of stone the back side of the stone that is intended to be laid; then the front wedges are gradually withdrawn, and the piece of stone then is inserted in the opposite direction, the stone being forced down to its place with blows of a mallet. The wooden wedges do not serve in this case to do more than prevent the stone from floating upon its bed of mortar. They hinder in this manner the undulation of the layer; they can be easily withdrawn by hand as soon as the bed of mortar has hardened a little.

The shrinkage that the Portland cement is exposed to ought to cause its rejection for the use of pointing mortars that are too rich. The best composition of this description of mortars seems to us to be that which is produced by a mixture of 700 parts of Portland cement to 1000 parts of gravel. To diminish as much as possible the porosity of the joints, it is necessary to stipulate for a most energetic method of the compression of them by the tool that is used to draw the joints—in French, by the *dagne*. The mortar is, moreover, much solidified by this operation. Now, we have had occasion to observe, practically, that bricks made with compressed mortar offer a resistance that is much greater than in bricks which are made in ordinary mortar prepared in the ordinary manner.

Amongst the remarkable properties of Portland cement mortars, it is important to mention that it is beyond the effects of frost. The Portland cement mortars do not freeze, as our masons say; and this allows the execution of masonry in the cement in the winter season in cases of need. Thus, portions of Portland cement mortar which we had exposed to the frost immediately after they were prepared, had cracked very deeply after they were made, and before they had taken their definite form, in consequence of the freezing of the water, and had even partially fallen to pieces to a great extent, but, after the thaw, had preserved, in the detached morsels, the greatest hardness.

We will terminate this note by some words upon the influence of the degree of tenacity of the inert matters mixed with the cements, and upon the ultimate resistance of the mortars. We for this purpose made bricks that were composed of the following ingredients, namely,

Rich mortar, } 1 of Portland cement and 2 (in bulk) of the gravel of la Creche.
1 of Portland cement and 2 of the Downs sand, (all in bulk.)
Thin mortar, } 1 of Portland cement and 4 of the gravel of la Creche.
1 of Portland cement and 4 of sand.

The sand that was obtained from the Downs was employed very fine; it did not leave any residue upon a sieve of eighteen meshes to the centimetre. The grains of gravel, on the contrary, were retained in about the proportion of one-third by this dimension of hole. We obtained the following resistance to tearing asunder that are found in this table :

Composition of the bricks.	Weight producing rupture by tearing asunder after—											
	5 days.		1 month.		3 months.		6 months.		1 year.		2 years.	
1 vol. Portland cem't 1 sand......	45 45 50 50 45 45	46·67	80 80 100 100 90 90	90·00	100 110 100 140 135 140	120·83	160 140 165 180 175 185	167·50	200 180 170	183·33	190 210 190	196·67
1 cement... 2 fine sand	40 40 42 42 47 47	43·00	80 80 110 110 100 100	96·67	110 120 117 80 100 100	104·50	145 145 145 155 150 140	146·66	180 150 160 160 140 140	155·00	190 190	190·00
1 Portland 4 gravel...	7·00 2·50 7·00 7·00 7·00 7·00	5·50	25 30 25 25 25 25	26·67	110 120 117 80 100 100	104·50	40 45 53 94 85 85	63·40	88 80 80 80 80 80	81·25	190 190	190·00
1 Portland 4 fine sand	2·50 2·59 2·50 2·50 2·50 2·50	2·50	10 12 10 10 10 10	10 67	110 120 117 80 100 100	104·50	15 25 36 30 25 25	30·20	35 42 42 42 42 42	38·50	190 190	190·00

It follows that the relation of the loads carried by the rich and the thin mortars, or those that were mixed with large proportions of sand, were as follows :

	After 5 days.	After 1 month	After 3 months.	After 6 months.	After 1 year.
Rich $\frac{\text{sand}}{\text{Grav'l}}$	$\frac{43·00}{40·67}=0·92$	$\frac{96·67}{90·00}=1·07$	$\frac{104·50}{120·83}=0·86$	$\frac{146·66}{167·50}=0·87$	$\frac{155·00}{183·33}=0·85$
Thin $\frac{\text{sand}}{\text{Grav'l}}$	$\frac{2·50}{5·50}=0·45$	$\frac{10·67}{26·67}=0·41$		$\frac{30·20}{63·40}=0·48$	$\frac{38·50}{81·25}=0·41$

After 2 years it was for rich mortars $\frac{190·00}{196·67}=0·96$.

This would lead to the prescription, in a general manner, of the use of fine sand in the preparation of thin mortars.

These materials are, then, carbonate of lime, nearly pure, to which the sea-water has added a little magnesia. We find, moreover, similar matters everywhere, that the water can penetrate through the mortar that is made of cement.

MECHANICS, PHYSICS, AND CHEMISTRY.

A Powerful Source of Artificial Light. By WILLIAM H. HARRISON.

From the British Journal of Photography, May, 1866.

One of the most brilliant discoveries made within the last few years has just been made public by its inventor, who has not only discovered a new principle in electrical science, but has applied it to the construction of a machine which, by means of the carbon points, will give light of much greater brilliancy than has hitherto been produced by man. The present apparatus is made on a grand scale, but it remains to be seen whether a small machine cannot be made to work by hand, whereby the electric light can be produced at the mere cost of the labor and the carbon electrodes. So powerful is the current of electricity evolved by the present apparatus, that ordinary photographic paper, at two feet distance from the light, blackens in twenty seconds to the same degree that it will darken by exposure for one minute to the direct rays of the noon-day sun on a clear morning in the month of March.

This invention was first made known to the public by Professor Faraday, a week or two ago, at a meeting of the Royal Society. The paper containing the information was a very long one, sufficient to fill more than a whole number of this *Journal*, and was written by the inventor, Mr. H. Wilde, of Manchester. Some notes of the substance of its contents, and the marvelous effects produced by the powerful currents evolved by the apparatus, will be of interest, considering the promise of the invention when regarded from a photographic point of view.

Mr. Wilde first made a large hollow metallic cylinder, with sides of iron, separated by a thick diaphragm of brass. This composite cylinder had its metallic parts bolted together by screws of brass. Permanent magnets could be placed over the cylinder, so that their poles would bite and make good contact with the opposite iron sides. The internal diameter of the cylinder was $1\frac{5}{8}$ inch. The four or five horseshoe magnets which could be placed over it, each weighed about one pound, and would each sustain a weight of ten pounds. Thus, when the magnets are mounted over the cylinder, the two iron sides of the latter become virtually the poles of one very powerful magnet. The armature is a long solid bar of soft iron, made to revolve inside the hollow portion of the cylinder. This solid bar has a deep longitudinal groove on each side of it, in which groove the insulated wires of the armature are placed, so that the latter has still a cylindrical form ex-

ternally. It will be noticed that this arrangement is, in principle, that of the ordinary magneto-electric machine, though somewhat differing in form from those of the usual construction.

With apparatus thus arranged, Mr. Wilde connected the terminal wires of the armature with a common tangent galvanometer, to measure the electricity evolved as each permanent magnet was added to the outside of the cylinder. He found that the electricity produced was in direct proportion to the number of magnets on the cylinder. But now comes the wonderful part of the discovery. When the induced current of electricity from the armature was passed round an ordinary electro-magnet, the soft iron bar, the latter actually lifted 178 lbs., whilst the four permanent magnets on the cylinder, the original source of the power, would only lift a weight of 40 lbs. The effect here produced seems to be out of all proportion to the cause, and it will be seen what an important bearing the discovery has upon the law of the conservation of energy. Having made this first step, Mr. Wilde constructed a second cylinder, larger than the first, and placed outside it electro-magnets instead of permanent magnets, the two machines being then worked together, and the current generated by the first being employed to excite the electro-magnets of the second. By this arrangement twenty-four inches of No. 20 iron wire, 0·04 inch in diameter, were made red-hot. Lastly, a machine with an iron armature ten inches in diameter was made, the total weight of the whole apparatus being four and a half tons. The three machines were then made to work together, the armature being driven, as before, by steam power, the results proving most astonishing. Pieces of cylindrical iron rods, each a quarter of an inch in diameter and fifteen inches in length, were melted by the current, which also melted seven feet of No. 16 iron wire, 0·065 of an inch in diameter, and made twenty-one feet of the same wire red-hot. Mr. Wilde says: "The illuminating power of the electricity from the intensity armature is, as might be expected, of the most splendid description. When an electric lamp, furnished with rods of gas-carbon half an inch square, was placed at the top of a lofty building, the light evolved from it was sufficient to cast the shadows from the flames of the street lamps a quarter of a mile distant upon the neighboring walls. When viewed from that distance the rays proceeding from the reflector have all the rich effulgence of sunshine. Lastly, as already stated, photographic paper is blackened in twenty seconds by this artificial light, to the same extent that it can be darkened by sunlight in a minute.

Such is the substance of the wonderful discovery made by Mr Wilde. It is evident that its value to the photographer is a question of expense, there being no doubt as to its utility. As the most economical proportions of the parts of such machines become better known by experience, it is to be hoped that the maximum of light and minimum of mechanical power, will be so altered from their present relative positions that the invention will be, to some extent, available to the photographer, and render him more independent of the weather. With the exception of the mechanical power, the expenses connected with

the working of the apparatus are nominal. Ordinary wear and tear, the consumption of the carbon points, and the gradual burning away of the contact places of the necessary commutators, are inexpensive items, offering no impediment to the general use of the machine. Whether the expense of the mechanical power can be so reduced as to make the invention commercially available in the photographic world, is the only question hanging over one practical application of this, one of the noblest scientific discoveries of modern times.

On a Convenient Process for Preparing Oxygen. By M. Fleitmann.*

From the London Chemical News, No. 287.

The easy preparation of oxygen for technical purposes is a matter of considerable importance, and I now shortly describe a process which possesses particular scientific interest. I was led to the process by observing that on heating a concentrated solution of chloride of lime, with only a trace of freshly prepared moist peroxide of cobalt,† the hypochlorite of lime was completely decomposed into chloride of calcium and oxygen. Repeated quantitative experiments, the results of which I have lost, convinced me that the whole of the oxygen was evolved, and that only chloride of calcium and no chloric acid was formed.

The evolution of oxygen commences about 70° or 80°, and continues in a regular stream, with a slight frothing of the liquid.

The action of the peroxide of cobalt in this case, it is clear, is exactly like that of nitric oxide in the manufacture of sulphuric acid. There is no doubt that several peroxides of cobalt, with various proportions of oxygen, exist. My own experiments have shown me that the proportion of oxygen in peroxide of cobalt is variable, and the simplest explanation of this process is that a lower peroxide abstracts oxygen from the hypochlorite of lime to form a higher oxide, which is again decomposed into a lower oxide and oxygen.

The peroxide made use of in one experiment may be employed again to decompose a fresh quantity of hypochlorite of lime. From one-tenth to one-half per cent. is sufficient to effect the reaction; and instead of taking the freshly prepared hydrated peroxide, it will suffice to add to the solution of hypochlorite a few drops of a solution of cobalt salt, whereby a corresponding amount of the peroxide is formed.

The advantages of this method of procuring oxygen appear to be the following:

1. The evolution proceeds with extraordinary regularity, and the gas is collected with the greatest ease, which makes the process specially applicable as a lecture experiment. When the mixture has been heated to 70° or 80°, the lamp may in general be removed, as the heat of the fluid is then sufficient to carry on the reaction to the end.

* *Annalen der Chemie und Pharmacie*, April, 1865, page 64.

† Peroxide of nickel acts in a similar way, but not so energetically.

2. The *whole* of the oxygen is obtained from the material, while only a part is procured by heating peroxide of manganese, and

3. The process has the advantage of greater cheapness than that with chlorate of potash (either with or without manganese.)

It is necessary to employ a clear solution of chloride of lime, as a thick or murky solution will froth over. The best way of making a clear and strong solution is by first extracting one portion of chloride of lime with water, decanting the clear liquor, and then making use of that to exhaust another portion of the chloride. In this way it is easy to get a liquor which will evolve from twenty-five to thirty times its volume of oxygen. On the small scale it is best to employ a capacious flask, which may be about seven-eighths filled with the solution. On a large scale, for technical purposes, a sort of steam boiler might be used, and the oxygen so obtained under pressure, and capable of being employed as a blast.

In a note the author suggests that a very pretty experiment may be made to show the displacement of oxygen by chlorine, by passing the latter gas into a mixture of solution of caustic soda with some peroxide of cobalt. The chlorine could be passed in on one side, and oxygen collected at the other.

The Chemistry of Gas Lighting. By Dr. Letheby.*

From the London Mechanics' Magazine, December, 1864.

The lecturer remarked that the object he had in view in the present instance was to take a rapid survey of the entire subject of the chemistry of gas manufacture. He did not intend to dwell particularly on any special set of facts; for, although every branch of the subject was full of interest, and might well be made the basis of elaborate investigation, yet the time at his disposal would not permit of anything more than a general and very cursory examination of the whole question. He would endeavor, therefore, to gather up the broad principles of chemical knowledge in this department of industry, and indicate their directive tendency. He hoped at a future time to have the opportunity of examining in detail the several branches of the subject; and at the very commencement of the inquiry it would be interesting to know something of the origin of the material upon which, as gas manufacturers, they had to operate. The question which here suggested itself was: Does chemistry throw any light upon the production of coal? There could be no doubt that it owed its origin to ligneous tissue. But how had it undergone those changes which had converted it into coal? Chemistry had pretty fully investigated this subject, and had shown that the production of coal was clearly traced to the eremacausis, or slow combustion of ligneous tissue; and in looking at the modes of oxidation of woody matter, it would appear that there were three ways in which it could be, and no doubt was,

* Abstract of a lecture delivered at Manchester before the British Association of Gas Managers.

effected. In the first place, it was partly effected by an internal change in the wood itself, whereby the elements—oxygen and hydrogen—associated and formed water, leaving the carbon free. In the second place, it was accomplished by the agency of water, the elements of which combined with carbon to form carbonic acid and marsh gas; and, thirdly, it was effected by the action of atmospheric oxygen slowly carried to the woody tissue by percolating water. All these changes were illustrated by diagrams and by specimens of wood in every stage of change, from lignite and Bovey coal to anthracite.

Formation of Coal.

Oak wood	$C_{36}H_{22}O_{22}$
Oak humus	$C_{35}H_{20}O_{20}$
Another humus	$C_{34}H_{18}O_{18}$
Brown coal	$C_{33}H_{21}O_{16}$
Another coal	$C_{32}H_{15}O_{9}$
Cannel coal	$C_{24}H_{13}O$
Caking coal	$C_{20}H_{9}O$
Anthracite	$C_{16}H\ O$

It was scarcely within the province of the present lecture to enter upon a detailed inquiry as to the best kinds of coal for the manufacture of gas, and he did not propose to say more than that the coal must be of that description called bituminous. But it was a matter of considerable importance to know whether any particular coal would yield a fair average proportion of gas without submitting it to minute analysis. In referring, therefore, to the varieties of coal which were best suited for the manufacture of gas, he directed attention to the rough

Composition of Gas Coals.

	Sulphur.	Ash.	Coke.	Volatile Matter.
Staffordshire—				
Maximum	3·10	3·50	66·00	42·90
Minimum	0·80	0·75	57·10	34·00
Average	1·71	2 01	61·61	38·39
Lancashire—				
Maximum	3·04	14·40	66 09	48·90
Minimum	0 52	1·09	51·10	33·91
Average	1·53	4·71	58 67	41·33
Newcastle—				
Maximum	2·85	9·12	72·31	45·17
Minimum	0 71	2·14	54·83	27·69
Average	1·29	4·52	61 24	38·76
Scotch—				
Maximum	1·58	8·05	59·15	45·06
Minimum	0·38	1·96	54·94	40·85
Average	1·22	5·46	57·32	42·68
Yorkshire—				
Maximum	1·40	10·50	66·90	38·00
Minimum	0·75	0·80	62·00	33·10
Average	1·19	2·96	64·37	35·63
Welsh—				
Maximum	2·30	7·55	88·23	41·58
Minimum	0·84	1·25	58·42	11·77
Average	1·09	3·66	64·37	35·63

test whereby the value of coal might be estimated; as, for example, the specific gravity of the specimen, which should be close to 1·3, and the loss encountered when a given quantity of the coal (say 100 grains) was ignited in a close vessel. The quality of the residue or the coke was also an indication of the value of the coal for gas purposes; and the lecturer exhibited a diagram of the average, the maximum, and the minimum amounts of coke and volatile matters in all the leading varieties of coal.

But there were certain impurities in coal which it became necessary to recognise. The three principal were ash or mineral matter, sulphur, and water, each of which had a very important influence on the manufacture of gas. The normal proportions of these impurities were illustrated by a series of diagrams of the compositions of various gas coals.

The modes of estimating these impurities were also referred to; and, in speaking of sulphur in coal, the lecturer alluded to the importance of making a selection of coals as free from it as possible, for Parliamentary legislation was manifestly towards the growing desire of the public to have gas with a minimum amount of sulphur. The means of determining the proportion of sulphur in coal were pointed out, and were illustrated by experiment. But, said the lecturer, there is another important question connected with this impurity in coal; in how many forms does it exist there? and of these, which are the most pernicious? He stated that it might, to a small extent, be there in a free state, and that of the combined forms it was perhaps associated with organic matter, as well as with iron, (bisulphide of iron,) and with lime as gypsum. The relative importance of each of these forms was dwelt upon, and he spoke of the pyritic form as the most objectionable, because of its giving off its sulphur at that temperature which is most favorable for the production of bisulphide of carbon and sulpho-hydrocarbons, both of which are unabsorbable impurities. The effect of moisture as an impurity was next referred to, and the lecturer explained how, when it was being distilled from the interior of a charge, and came into contact with the protosulphide of iron which had already parted with half of its sulphur, the aqueous vapor decomposed the sulphide, and formed sulphuretted hydrogen and oxide of iron, thus adding to the cost of the preparation.

The lecturer then directed attention to the facts which had been ascertained in respect of the temperature best suited for the destructive distillation of coal. He remarked generally that the action of heat on organic matters was to disturb the existing equilibrium of affinities, and thus to give the elements an opportunity of arranging themselves into other and simpler groups. The order of the movement of the molecules of organic matter, when subjected to heat, was somewhat as follows: After the hygrometric or physical moisture had been dissipated, oxygen was the first to start in the race of thermotic change. It combined with hydrogen to form water, with carbon to form carbonic acid, and with carbon and hydrogen to form acid and spirituous compounds, comparatively rich in oxygen, and which are mixable with water. Next to move, perhaps, was the hydrogen in

its combination with carbon to form solid and liquid hydrocarbons of the nature of paraffin and paraffin oil and benzole, which were not mixable with water. At a higher temperature the nitrogen combined with hydrogen to form ammonia and with carbon and hydrogen to form pyrogenous alkaloids, and with carbon alone to produce cyanogen. At this temperature, also, the sulphur took hydrogen to form sulphuretted hydrogen, and then carbon and hydrogen to form the sulpho-carbohydrogens; and, lastly, with carbon alone to form bisulphide of carbon. Finally, gaseous hydrocarbons were freely produced; and during all the time of distillation, many of the primary compounds, by coming into contact with the red-hot coke and with the sides of the retort, underwent change, and were converted into secondary products, as naphthaline, &c.

The temperatures at which these changes were effected had been tolerably well ascertained. Up to the temperature of 700° Fahr., little or no change was effected in the coal beyond the evolution of physical moisture. At the temperature of melting zinc, (773° Fahr.,) a little chemical moisture with an empyreumatic odor was produced. At 980°, which is a red heat just visible in the dark, water and fat oils—the paraffin series—begin to distil, but there is little or no gas. At 1500°, which is a cherry-red, gas of high illuminating power is copiously evolved, and spirituous oils, rich in carbon, also appear. At a full red heat, (1800°,) and from this to incipient whiteness, permanent gases of poor illuminating power, as carbonic oxide, marsh gas, and hydrogen, and pernicious sulphur compounds, are freely evolved. Practically, therefore, it may be said that the best temperature for distilling common gas coals is a cherry-red, (1500°,) and for cannel coals a full red, (1800°.)

In illustration of the difference of the products when cannel coals are distilled at a high and low temperature, Dr. Letheby alluded to the quality of the tar in the two cases. The tar produced at a high temperature was always heavier than water—specific gravity ·12 to 1·15; it dried freely in the air by oxidation; it contained hydrocarbons with such an excess of carbon, that they could not be burnt in a common lamp; they were almost totally destroyed by strong oil of vitriol; they contained sulphur, and their per centage composition was about 86 carbon, 7 hydrogen, 7 oxygen, and a little sulphur—about 0·5 per cent. Whereas the tar produced at a low temperature was lighter than water—about ·900 specific gravity; it would not oxidate or dry in the air; it contained hydrocarbons of the paraffin series, which are comparatively poor in carbon, and which can be burnt in a lamp; they are not much acted upon by strong oil of vitriol; they contain but little or no sulphur, and their per centage composition is about 84 carbon, 12 hydrogen, and 4 oxygen. So also with the gases; at a temperature below 1800° they are rich in hydro-carbons of high illuminating power, and at a higher temperature they are comparatively poor in such hydrocarbons. The nature of the coal, of course, makes a large difference in the results, but the general expression of the fact is, that high temperatures make a minimum quan-

tity of tar, rich in carbon, and much gas, with comparatively poor illuminating power, and with large proportions of sulphur compounds.

The raw gas, as it leaves the retort, consists of aqueous vapor, vapor of tar, carbonic acid, carbonic oxide, ammonia, cyanogen, sulphocyanogen, sulphuretted hydrogen, bisulphide of carbon, sulpho-hydrocarbons, hydrogen, light carburetted hydrogen, olefiant gas, &c. Most of these are useless as illuminating agents, and, therefore, the necessity for purification. Fortunately, this, to a large extent, is easily effected by a natural process of condensation. As the gases and vapors cool, the condensable portions separate as liquid products, and thus in the hydraulic main and in the condensers, the oily tar and the aqueous ammoniacal liquor separate of their own accord. The indications, therefore, of this first step of natural purification is to cool the raw gas as much as possible. But even when thus cooled it contains a large proportion of impurity which is soluble in water; and hence, the next indication is the necessity for the use of a contrivance which shall bring the gas into contact with an aqueous solvent. Looking at the variable quality or composition of ammoniacal liquor, and that the proportion of ammonia in it ranges from about 1000 grains in the gallon to about 4000, or, in other words, that the saturating power of it per gallon is from about 6 ounces of the strongest sulphuric acid to 26 ounces, it is manifest that the best and proper washing liquid is ammoniacal liquor. This ought never to leave the gas works with less than 2000 grains of ammonia in it per gallon, or with a less saturating power than 13 ounces of sulphuric acid. There is no reason, indeed, why it should not always contain nearly double this quantity of ammonia. The use, therefore, of ammoniacal liquor as a washer of the raw gas is a natural inference. It was first suggested by Mr. Hawksley, and he has put it into practice with excellent effect, for not only does the ammoniacal liquor afford a means of removing ammonia, sulphuretted hydrogen, and carbonic acid from the raw gas, but, being already saturated with hydrocarbons, it does not take up any more of these illuminating agents; besides which, it can be used as a *douche* in such quantity in a large washer, that it operates very successfully as a cooling agent. The suggestions, indeed, of Mr. Laming, that every charge of ammoniacal liquor thus used might be first filtered through hydrated oxide of iron, so as to move the sulphuretted hydrogen, and thus give it a more effective purifying power, is not without practical value. But even when the gas has been thus cooled, and has left the condensers, it is not so free from ammonia, carbonic acid, and sulphuretted hydrogen as that a small quantity of water properly distributed in a scrubber will not still further purify it, and the arrangement should be such that the water should trickle very slowly over a large surface, and reach the bottom of the scrubber almost saturated with impurities. Leaving this part of the apparatus, the raw gas should never contain more than 1 volume in 1000 of ammonia, 8 of sulphuretted hydrogen, and 20 of carbonic acid. These are in the proportion of 315 grains of ammonia, 5048 grains of sulphuretted hydrogen, and 16,336 grains of carbonic acid in 1000 cubic

feet of gas. Then comes the chemical means whereby these can be best removed, and this involves an inquiry into the action of the purifiers, as they are called.

The order in which these impurities should be taken out is a matter of no slight importance. Chemistry teaches us that the first impurity to be removed is ammonia, for its presence checks the withdrawal of carbonic acid and sulphuretted hydrogen. Among the many suggestions which have been made for the absorption of ammonia, there is none so effective as diluted sulphuric acid, and it is found that 49 parts by weight of the strongest sulphuric acid will remove 17 of ammonia. It will take, therefore, 909 grains, or rather more than 2 ounces of sulphuric acid, to remove the ammonia from the 1000 cubic feet of gas. The acid is best used diluted with about its own bulk of water, and sprinkled upon saw-dust, which should be placed first in the trays of the purifiers; and the saw-dust thus saturated with the ammonia is a valuable material, as it should contain fully half its weight of sulphate of ammonia. Other valuable absorbing agents have been proposed, as the spent acids of various manufacturing processes, the acid salt of alumina obtained by boiling clay shale with sulphuric acid, (Croll,) and the residual chloride of manganese from bleaching works. This has recently been used by Mr. Croll in the form of a nearly dry mixture with saw-dust, and it yields a salt of ammonia remarkably free from impurities.

Next after the ammonia, it is proper to remove the sulphuretted hydrogen, and unquestionably, if no sanitary considerations are concerned, the best agent for this purpose is wet lime, a material which will not only remove the sulphuretted hydrogen, but will likewise absorb the carbonic acid. Theoretically, 28 parts by weight of lime will take up 17 of sulphuretted hydrogen, and another 28 parts will take up 22 of carbonic acid. It follows, therefore, that about 3 lbs. of lime will absorb the carbonic acid, and $1\frac{1}{4}$ lb. the sulphuretted hydrogen in the 1000 cubic feet of gas, taking altogether about $42\frac{1}{2}$ lbs. of lime for 10,000 cubic feet of gas. But this is on the supposition that the lime is thoroughly effective, and that it is used in a very wet state; practically, it is not so completely effective, and hence it takes about 50 lbs. of wet lime to purify 10,000 cubic feet of gas. If the lime is used in a dry state, (as a hydrate,) it is by no means so effective, for it requires fully twice the quantity of lime to purify the gas. This is due to the circumstance that the interior of the little lumps of lime is never reached by the gas, and therefore remains inoperative; besides which, the lime is getting constantly drier in the purifiers by the heat of combination with the impurities of the gas, and as the lime dries, it loses its capacity for absorbing these impurities; absolutely dry lime, in fact, will scarcely absorb sulphuretted hydrogen.

The offensive nature of spent lime, or blue billy, is such that a demand has been made on science to furnish a less objectionable means of purification; and hence the use of the hydrated oxide of iron—a material which, when tolerably pure, will absorb sulphuretted hydrogen in the proportion of 17 parts of sulphuretted hydrogen to about

33 of the oxide. It will take, therefore, about 14 lbs. of the hydrated oxide to remove the sulphuretted hydrogen from 10,000 cubic feet of gas. It has then become a sulphide of iron, and has lost its power of purification, and must be revived. This is accomplished by simply exposing the oxide to the air, when it takes in atmospheric oxygen, and again passes into the state of hydrated oxide of iron, while the sulphur is set free in the mixture. The oxide thus charged is then used again and again, until it becomes charged to the extent of about 57 per cent. of sulphur, when it is no longer effective. Practically, a ton of oxide will, by successive revivification, purify about 5,000,000 cubic feet of gas, and will absorb about 3600 lbs. of sulphuretted hydrogen. When thus charged with sulphur, it is valuable for manufacturing oil of vitriol.

If hydrated oxide of iron has been used as the purifier, lime must also be afterwards employed for the purpose of removing the carbonic acid, which is so destructive of the light of the gas when it is burned.

Having left the purifiers, the constituents of the gas are as follow:

	Per cent.		
Hydrogen	25	to	50
Light carburetted hydrogen, $C^2 H^4$	35	"	52
Olefiant gas, $C_4 H_4$	3	"	20
Propylene, $C_6 H^6$			
Butylene, $C_8 H^6$			
Other hydrocarbons, $C_n H_n$			
Benzole vapor, $C_{12} H^6$			
Acetylene, $C_4 H^2$			
Carbonic oxide, $C O$	5	"	9
Carbonic acid, $C O_2$	0	"	2
Cyanogen, $C_2 N$	?	"	?
Ammonia, $N H_3$	0·01	"	0·06
Bisulphide of carbon, $C S_2$	?	"	?
Sulpho-hydrocarbons	?	"	?
Aqueous vapor	2	"	3
Oxygen	0	"	1
Nitrogen	0	"	8

The properties of each of these constituents were demonstrated by experiment, and reference was made to their specific gravities, to their combining volumes, to the proportion of oxygen which they required for combustion, to the quantity of carbonic acid so produced, to the heat evolved, and to the action of water, chlorine, bromine, and anhydrous sulphuric acid upon them.

One of the interesting features of this part of the lecture was the production of acetylide of copper from the coal gas of the hall, and the exhibition of acetylene in large volume; as also the production of nitro-benzole from the gas, by passing it through fuming nitric acid.

As regards the means of determining the proportions of the condensable hydrocarbons in coal gas, Dr. Letheby showed that, as all the illuminating constituents of coal gas, excepting the light carburetted hydrogen, were absorbed by bromine and by anhydrous sulphuric acid, neither of these tests were worth anything as an indication of the illuminating power of the gas. In speaking of acetylene, he alluded to the fact that its production by the intense ignition of carbon in hydrogen was a remarkable example of the production of a hydrocarbon by the immediate combination of its elements; and he observed that

as acetylene, which is such a powerful illuminating agent, may be made by the action of carbonic oxide on light carburetted hydrogen at high temperatures, it is possible that hereafter it will be found that by a proper arrangement of apparatus, a high temperature may be best suited for the production of illuminating gas. The sole difficulty,

Principal Constituents of Coal-tar.

	Formulas.	Boiling points. Degrees Fahrenheit.
Acids—		
Acetic	$C_4 H_4 O_4$	248
Butylic	$C_8 H_8 O_4$	315
Phenic	$C_{12} H_6 O_8$	370
Cresylic	$C_{14} H_8 O_2$	397
Phlorylic	$C_{16} H_{10} O_2$	...
Rosolic	$C_{24} H_{12} O_6$	...
Brunolic	?	...
Neutral—		
Propylene	$C_6 H_6$	...
Butylene	$C_8 H_8$	54
Amylene	$C_{10} H_{10}$	102
Caproylene	$C_{12} H_{12}$	131
Alliaceous	?	?
Benzole	$C_{12} H_6$	176
Toluole	$C_{14} H_8$	237
Xylole	$C_{16} H_{10}$	259
Cumole	$C_{18} H_{12}$	302
Cymole	$C_{20} H_{14}$	347
Naphthaline	$C_{20} H_8$	414
Anthracene,	$C_{28} H_{10}$	...
Paraffin	$C_n H_n$	...
Pyrene	$C_{30} H$	...
Chrysene	$C_{12} H_4$	...
Alkalies—		
Ammonia	$H_3 N$	...
Methylamine	$C_2 H_5 N$	...
Ethylamine,	$C_4 H_7 N$	66
Petinine	?	176
Cespitine	$C_{10} H_{13} N$	205
Pyrrhidine	$C_{10} H_5 N$	271
Picoline	$C_{12} H_7 N$	273
Lutidine	$C_{14} H_9 N$	309
Collidine	$C_{16} H_{11} N$	338
Aniline	$C_{12} H_7 N$	360
Parvoline	$C_{18} H_{13} N$	370
Toluidine	$C_{14} H_9 N$	388
Coridine	$C_{20} H_{15} N$	412
Xylidine	$C_{16} H_{11} N$	415
Cumidine	$C_{18} H_{13} N$	437
Rubidine	$C_{22} H_{17} N$	446
Cryptidine	$C_{22} H_{11} N$	...
Leucoline	$C_{18} H_7 N$	455
Cymidine	?	462
Viridine	$C_{24} H_{19} N$	484

perhaps, to be overcome will be the formation of carbonic oxide and marsh gas in proper proportions.

With respect to the existence of sulphur compounds in coal gas,

Dr. Letheby demonstrated by many experiments that sulphide of carbon and one or more sulpho-hydrocarbons were always present; and he showed the patented processes of Mr. Bowditch, Dr. Stenhouse, and Dr. Angus Smith, for removing these sulphur compounds. He referred also to his own apparatus for estimating the amount of sulphur in purified coal gas; and he likewise explained the means of determining the proportion of ammonia in gas, and he spoke of this impurity as a purveyor of the offensive tar-like hydrocarbons.

A slight reference was made to the subject of coal-tar, and to the large field of chemical research which it had exposed to the chemist; and a few of the more interesting of the coal-tar pigments were made, and nearly all the products were exhibited on the table, (*page* 44.)

Lastly, in respect of the chemistry of the combustion of gas, Dr. Letheby showed under what circumstances it was best consumed, and he demonstrated in various ways, as by Erdmann's gas-prover, that the proper illuminating power of coal gas could only be obtained by an accurate adjustment of the air to the gas. This was chiefly accomplished in the Argand burner by a proper adaptation of the internal aperture to the quality of the gas; a burner of only 0·42 of an inch internal bore, was well suited for 11-candle gas, one of 0·44 of an inch for 13-candle gas, and one of 0·50 of an inch for 15-candle. In each of these cases the burner is used without a gauze diaphragm, and with a 7-inch chimney, the gas being burned at the rate of 5 feet an hour; but the same result and a steadier flame is obtained by using Sung's burner of a little smaller diameter of the internal hole in each case, and a gauze diaphragm. By experiment with Leslie's burner, which is altogether unsuited for gas of low illuminating power, it was shown that the light of the gas might be seriously destroyed.

The relative values of different illuminating agents were shown by the following table:

Relative values of Illuminating Agents in respect of their Heating and Vitiating Effects on the Atmosphere, and Burning so as to give the Light of Twelve Standard Sperm candles.

	Pounds of water heated to 1° Fahr.	Oxygen consumed, (cubic feet.)	Carbonic acid produced, (cubic feet.)	Air vitiated, (cubic feet.)
Cannel gas	1950	3·30	2·01	50·9
Common gas	2786	5·45	3·21	80·2
Sperm oil	2335	4·75	3·33	83·3
Benzole	2326	4·46	3 54	88·5
Paraffin	3619	6·81	4·50	112·5
Camphine	3251	6·65	4·77	119·2
Wax candles	3831	8·41	5 90	149·5
Sperm "	3517	7·57	5·27	131·7
Stearic "	3747	8 82	6·25	156·2
Tallow "	5054	12·06	8·73	218·3

In conclusion, the lecturer observed that every day brought to light some new fact connected with the chemistry of gas manufacture, which deserved the careful consideration of all who, like those to whom he was addressing himself, were practically engaged in this important branch of industry. He had endeavored to lay before them, with as much fulness as time allowed, the most prominent features of the question, as far as the light of science had at present elucidated them; but the subject, in all its details, was far too complex to allow of more than a mere general statement in a compass of a single lecture.

On Scientific Experiments in Balloons. By JAMES GLAISHER, Esq., F. R. S., &c.

Proceedings of the Royal Institution of Great Britain, No. 41.

Mr. Glaisher, at the beginning, referred to the discourse given by him two years since, when he had made eight ascents, for the purpose of scientific researches, in the higher regions of the atmosphere, and said since that time he had made seventeen additional. He described the process of filling a large balloon, and briefly described a balloon ascent, speaking of the novel sensation at first experienced, of the extreme coldness and dryness of the air at great elevations, of the painless death awaiting the aërial traveler who should ascend to an elevation too great for his power of endurance, and compared it to that of the mountain traveler, who, benumbed and insensible to suffering, yields to the lethargy of approaching sleep, and reposes to wake no more. Moral energy in both cases, he stated, was the only means of safety.

He then exhibited the several instruments used, pointing out their extreme sensitiveness and delicacy, and then spoke of the primary objects of balloon research.

Subjects of Research by Means of Balloons.—1st. To determine the rate of decrease of temperature with increase of elevation; and to ascertain whether the results obtained by observations on mountain sides, viz: a lowering of temperature of 1° for every increase of elevation of 300 feet, be true or not.

2d. To determine the distribution of the water, in the invisible shape of vapor, in the air below the clouds, and above them, at different elevations.

3d. To compare the results, as found by different instruments, together:

1. The temperature of the dew point as found by—
   - Dry and wet thermometers, (free.)
   - Dry and wet thermometers, (aspirated, or air made to pass rapidly.)
   - Daniell's dew-point.
   - Regnault's dew-point, (blowing.)
   - Regnault's dew-point, (air made to pass rapidly.)
2. To compare the readings of—
   - Mercurial and aneroid barometers, &c.

4th. Solar radiation, by taking readings of the blackened bulb thermometer fully exposed to the sun, with simultaneous observations of

the dry-bulb thermometer, and also of observations of Herschel's Actinometer.

5th. To determine whether the solar spectrum, when viewed from the earth, and far above it, exhibited any difference; whether there were a greater or less number of dark lines crossing it, particularly when near sun-setting.

6th. To determine whether the horizontal intensity of the earth's magnetism was less or greater with elevation.

Propagation of sound.

Amount of ozone, &c.

In every ascent a second or third thermometer, differently graduated, has been used to check the accuracy of the readings of the dry thermometer, and the truthfulness of the temperature shown by it. In some of the ascents a delicate blackened bulb thermometer was placed near to the place of the dry-bulb thermometer, fully exposed to the sun in cloudless skies, or to the sky at all times. The readings of this instrument were nearly identical with those of the dry-bulb thermometer in clouded states of the sky, and thus acted as an additional check.

At all times, one or the other, or both, Regnault's and Daniell's hygrometers have been used sufficiently often, at all heights, to show whether the wet-bulb thermometer was in proper action, and to check the results given by the use of the dry and wet-bulb thermometer on the reduction of the observations.

The author said he would not give a detailed account of the experiments in the years 1862 and 1863, as they were published, but would confine himself to some of the results.

He said it was soon found that the state of the sky exercised a great influence, and the experiments had to be repeated with two groups, one with cloudy skies, and the other with clear skies.

The results are as follow:

The Decline of the Temperature of the Air with Elevation, when the Sky was Cloudy.

	Feet.		Feet.		Deg.				Feet.
From	0	to	1,000	was	4·2	from	17	experiments, or 1 degree in	223
"	1,000	"	2,000	"	3·6	"	21	"	278
"	2,000	"	3,000	"	3·7	"	22	"	271
"	3,000	"	4,000	"	3·4	"	20	"	295
"	4,000	"	5,000	"	3·3	"	13	"	333
"	5,000	"	6,000	"	3·2	"	7	"	313
"	6,000	"	7,000	"	2·7	"	5	"	371
"	7,000	"	8,000	"	2·4	"	4	"	417
"	8,000	"	9,000	"	2·2	"	4	"	455
"	9,000	"	10,000	"	2·2	"	4	"	455
"	10,000	"	11,000	"	2·2	"	4	"	455
"	11,000	"	12,000	"	2·2	"	4	"	455
"	12,000	"	13,000	"	2·2	"	4	"	455
"	13,000	"	14,000	"	2·3	"	4	"	435
"	14,000	"	15,000	"	2·0	"	4	"	500
"	15,000	"	16,000	"	2·1	"	4	"	477
"	16,000	"	17,000	"	1·2	"	2	"	833
"	17,000	"	18,000	"	1·3	"	2	"	771
"	18,000	"	19,000	"	1·4	"	2	"	715
"	19,000	"	20,000	"	0·9	"	2	"	909
"	20,000	"	21,000	"	1·1	"	2	"	911
"	21,000	"	22,000	"	0·8	"	2	"	1,250
"	22,000	"	23,000	"	0·8	"	2	"	1,250

These results show, when the sky is cloudy, the decline of temperature at every 1000 feet increase of elevation. Up to 5000 feet the number of experiments upon which each result is based vary from 13 to 22; at 6000 and 7000 feet to 7 and 5, respectively; from 7000 to 16,000 feet to 4; these having been made on two days, viz: 1863, June 26 and September 29, on which days the balloon was frequently enveloped in fog and clouds to the height of three and four miles, and those above 16,000 feet on the former of these two days only, during the ascent and descent, the sky being still covered with cloud when the balloon was between 4 and 5 miles high.

The Decline of the Temperature of the Air with Elevation, when the Sky was Clear, or chiefly Clear.

	Feet.		Feet.		Deg.				Feet.
From	0	to	1,000	was	6·2	from	9	experiments, or 1 degree in	162
"	1,000	"	2,000	"	4·7	"	9	"	213
"	2,000	"	3,000	"	3·8	"	11	"	264
"	3,000	"	4,000	"	3·3	"	12	"	304
"	4,000	"	5,000	"	2·9	"	12	"	345
"	5,000	"	6,000	"	2·6	"	17	"	385
"	6,000	"	7,000	"	2·5	"	15	"	401
"	7,000	"	8,000	"	2·7	"	12	"	371
"	8,000	"	9,000	"	2·5	"	12	"	400
"	9,000	"	10,000	"	2·4	"	12	"	417
"	10,000	"	11,000	"	2·6	"	13	"	385
"	11,000	"	12,000	"	2·3	"	11	"	435
"	12,000	"	13,000	"	2·2	"	11	"	455
"	13,000	"	14,000	"	2·0	"	11	"	500
"	14,000	"	15,000	"	1·7	"	9	"	588
"	15,000	"	16,000	"	2·2	"	9	"	455
"	16,000	"	17,000	"	1·9	"	7	"	526
"	17,000	"	18,000	"	1·7	"	7	"	588
"	18,000	"	19,000	"	1·5	"	7	"	666
"	19,000	"	20,000	"	1·3	"	7	"	771
"	20,000	"	21,000	"	1·2	"	7	"	833
"	21,000	"	22,000	"	1·1	"	7	"	911
"	22,000	"	23,000	"	1·0	"	4	"	1,000
"	23,000	"	24,000	"	1·3	"	2	"	771
"	24,000	"	25,000	"	1·1	"	2	"	909
"	25,000	"	26,000	"	1·0	"	1	"	1,000
"	26,000	"	27,000	"	1·0	"	1	"	1,000
"	27,000	"	28,000	"	0·9	"	1	"	1,111
"	28,000	"	29,000	"	0·8	"	1	"	1,250

Up to the height of 22,000 feet the number of experiments vary from 7 to 17, and there can be but little doubt that the number showing the decrease of temperature are very nearly true, and approximate closely to the general law. Above 24,000 feet the number of experiments are too few to speak confidently upon them, but they are in accordance with the series deduced from the experiments at less elevations.

A decline of temperature under a clear sky of 1° takes place within 100 feet of the earth, and at heights exceeding 25,000 feet it is necessary to pass through 1,000 feet of vertical height, as appears in the last column of the preceding table, for a decline of 1° of temperature.

By adding together, successively, the decline of temperature for each 1000 feet the whole decrease of temperature from the earth to the different elevations is found. The results, with a cloudy sky, are as follow:

When the Sky was Cloudy.

Feet.	Feet.		Deg.		Feet.
From 0 to	1,000	the decrease was	4·5	or 1 deg. on the average of	223
" 0 "	2,000	"	8·1	"	247
" 0 "	3,000	"	11·8	"	255
" 0 "	4,000	"	15·2	"	263
" 0 "	5,000	"	18·5	"	271
" 0 "	6,000	"	21·7	"	277
" 0 "	7,000	"	24·4	"	287
" 0 "	8,000	"	26·8	"	299
" 0 "	9,000	"	29·0	"	311
" 0 "	10,000	"	31·0	"	321
" 0 "	11,000	"	33·0	"	329
" 0 "	12,000	"	35·6	"	337
" 0 "	13,000	"	37·8	"	344
" 0 "	14,000	"	40·1	"	349
" 0 "	15,000	"	42·1	"	356
" 0 "	16,000	"	44·2	"	362
" 0 "	17,000	"	45·4	"	375
" 0 "	18,000	"	46·7	"	386
" 0 "	19,000	"	48·1	"	395
" 0 "	20,000	"	49·0	"	409
" 0 "	21,000	"	50·1	"	419
" 0 "	22,000	"	50·9	"	432
" 0 "	23,000	"	51·7	"	445

These results, showing the whole decrease of temperature of the air from the earth up to 23,000 feet, differ very considerably from those with a clear sky, to be spoken of presently. The number in the last column show the average increment of height for a decline of 1°, as found by using the temperature of the extremities of the column alone. To 1000 feet high the average is 1° in 223 feet, increasing gradually to 1° in 445 feet at 23,000 feet.

When the Sky was Clear, or chiefly Clear.

Feet.	Feet.		Deg.		Feet.
From 0 to	1,000	the decrease was	6·2	or 1 deg. on the average of	162
" 0 "	2,000	"	10·9	"	184
" 0 "	3,000	"	14·7	"	204
" 0 "	4,000	"	18·0	"	223
" 0 "	5,000	"	20·9	"	239
" 0 "	6,000	"	23·5	"	256
" 0 "	7,000	"	26·0	"	271
" 0 "	8,000	"	28·7	"	279
" 0 "	9,000	"	31·2	"	289
" 0 "	10,000	"	33·6	"	298
" 0 "	11,000	"	35·6	"	309
" 0 "	12,000	"	37·9	"	317
" 0 "	13,000	"	40·1	"	324
" 0 "	14,000	"	42·1	"	333
" 0 "	15,000	"	43·8	"	343
" 0 "	16,000	"	46·0	"	348
" 0 "	17,000	"	47·9	"	355
" 0 "	18,000	"	49·6	"	363
" 0 "	19,000	"	51·1	"	372
" 0 "	20,000	"	52·4	"	382
" 0 "	21,000	"	53·6	"	392
" 0 "	22,000	"	54·7	"	405
" 0 "	23,000	"	55·7	"	413

	Feet.		Feet.		Deg.		Feet.
From	0	to	24,000	the decrease was	57·0	or 1 deg. on the average of	422
"	0	"	25,000	"	58·1	"	431
"	0	"	26,000	"	59·1	"	441
"	0	"	27,000	"	60 1	"	449
"	0	"	28,000	"	61·0	"	459
"	0	"	29,000	"	61·8	"	469
"	0	"	30,000	"	62·3	"	482

These results, showing the whole decrease of temperature from the ground to 30,000 feet, differ greatly, as just mentioned, from those with a cloudy sky.

The numbers in the last column, showing the average increase of height for a decline of 1° of temperature from the ground to that elevation, are all smaller than those with a cloudy sky at the same elevation. Each result is based upon at least seven experiments, taken at different times of the year, and up to this height considerable confidence may be placed in the results. They show that a change takes place in the first 1000 feet of 1° on an average in 162 feet, increasing to about 300 at 10,000 feet. In the year 1862 this space of 300 feet was at 14,000 feet high, and in 1863 at 12,000 feet. Therefore the change of temperature has been less in 1863 than that in 1862, and less in 1864 than in 1863, but the experiments have all been taken at different times of the year.

Without exception the fall of 1° has always taken place in the smallest space when near the earth.

Treating the observations for determining the degrees of humidity of the air in the same way, the following are the results:

When the sky was cloudy, saturation being considered as 100, the degree of humidity on the earth was	74	from	19	experiments.
At 1,000 feet	76	"	33	"
" 2,000 "	76	"	34	"
" 3,000 "	78	"	35	"
" 4,000 "	75	"	27	"
" 5,000 "	74	"	16	"
" 6,000 "	73	"	14	"
" 7,000 "	62	"	11	"
" 8,000 "	54	"	11	"
" 9,000 "	50	"	11	"
" 10,000 "	48	"	10	"
" 11,000 "	47	"	10	"
" 12,000 "	52	"	6	"
" 13,000 "	58	"	6	"
" 14,000 "	52	"	5	"
" 15,000 "	59	"	3	"
" 16,000 "	59	"	2	"
" 17,000 "	47	"	2	"
" 18,000 "	33	"	2	"
" 19,000 "	24	"	2	"
" 20,000 "	29	"	2	"
" 21,000 "	22	"	2	"
" 22,000 "	34	"	1	"
" 23,000 "	40	"	1	"

The law of moisture here shown is a slight increase from the earth to the height of 3000 feet, and then a slight decrease to 6000 feet, the degree of humidity being at this elevation nearly of the same value as on the ground. From 6000 to 7000 feet there is a large decrease,

and then an almost uniform decrease to 11,000 feet; it increases from 12,000 to 16,000 feet, and then decreases; the number of experiments up to 11,000 feet vary from 10 to 33; and I think good confidence may be placed in the result to this elevation, but at heights of 12,000 feet the number of experiments are evidently too small to speak with any confidence in respect to the results.

By treating the results with a clear, or a nearly clear sky, in the same way, the following results were obtained:

With a clear sky the degree of humidity on the ground was	59	from	9	experiments.
At 1,000 feet	61	"	14	"
" 2,000 "	70	"	17	"
" 3,000 "	71	"	23	"
" 4,000 "	71	"	19	"
" 5,000 "	69	"	17	"
" 6,000 "	62	"	15	"
" 7,000 "	56	"	16	"
" 8,000 "	50	"	14	"
" 9,000 "	50	"	9	"
" 10,000 "	46	"	18	"
" 11,000 "	43	"	10	"
" 12,000 "	35	"	8	"
" 13,000 "	37	"	7	"
" 14,000 "	37	"	7	"
" 15,000 "	44	"	5	"
" 16,000 "	40	"	5	"
" 17,000 "	39	"	4	"
" 18,000 "	21	"	2	"
" 19,000 "	36	"	2	"
" 20,000 "	33	"	1	"
" 21,000 "	32	"	1	"
" 22,000 "	21	"	1	"
" 23,000 "	16	"	1	"

The law of moisture here shown is a slight increase to 1000 feet, a considerable increase between 1000 and 2000 feet, a nearly constant degree of humidity from 2000 to 5000 feet, and a gradual decrease afterwards to 12,000 feet. At greater heights the numbers are less regular. The results up to 11,000 feet are based upon experiments varying from 10 to 23, and are most likely very nearly true normal values. At heights exceeding 12,000 feet the number of experiments have varied from 1 to 8, and no general confidence can be placed in them.

By comparing the results from the two states of the sky, the degree of humidity of the air up to 1000 feet high is 15 less with a clear sky than with a cloudy; from 2000 to 5000 is from 4 to 6 less; at 6000 feet the air with a clear sky is much drier than at 5000 feet, but with a cloudy sky it is nearly of the same degree of humidity, so that the difference between the two states is large, amounting to no less than 11; the difference decreases to 0 at 9000 feet, but increases to 4 at 11,000 feet; at heights exceeding 11,000 feet the air with clear skies generally becomes very dry, but with cloudy skies frequently becomes more humid, as was to be expected from the fact of the presence of clouds at heights exceeding three and four miles.

In both states of the sky, at extreme elevations, the air becomes very dry, but, so far as my experiments go, is never free from water.

(To be continued.)

For the Journal of the Franklin Institute.

Paraselené.

At 11 o'clock, on Sunday night, the 1st inst., when the altitude of the moon was about 45°, the attention of the writer was attracted by a bright nebulus appearance, twice the apparent diameter of that luminary, in the circumference of a semi-circular corona, unusually broad, and 60° in diameter.

Although there were fleecy clouds floating in the sky at the time of observation, the writer was at once convinced of the different character of the nebulus spot observed; and his convictions as to its nature induced him to make further investigations.

A less obstructed view of the heavens than his first observation afforded, disclosed another nebulus spot, similar to that already described, in the circumference of the corona on the opposite side of the moon and equidistant therefrom.

The sky had a slightly watery appearance at the hour indicated and was shortly afterward quite overcast. The attendant phenomena were similar to those accompanying parhelion, twice witnessed by the writer.

If any of the readers of the *Journal* have witnessed phenomena similar to those herein described, or can refer the writer to any record of such, their advising him of the fact will be esteemed a favor.

C. J. W., Jr.

Germantown, April 8, 1866.

MISCELLANIES.

Cast Iron.—M. Gaudin reports that, while experimenting in an ordinary cupola furnace, by melting iron at a very high temperature, with phosphate of iron and peroxide of manganese, he succeeded in obtaining a species of iron, very hard and not forgeable, but turning well, and applicable to the manufacture of pieces which require great strength. The metal is remarkably sonorous, and might, perhaps, be applied to the casting of bells.

New Mortar. By Dr. Artus.—The mortar used by the Romans has, in the course of ages, set so strongly as to be equal in hardness to the stones which it was used to cement, and an analysis of it shows that this is to be attributed to the abundant formation of silicate of lime throughout the mass. The modern mortar, on the other hand, for the most part, hardens slowly, cracks while hardening, has but little adhesion, and its useful effect is simply as a bed for the proper support of the stone or brick upon its whole surface, and the consequent distribution of the pressures properly over the sustaining masses. Analysis shows little or no formation of silicates, and the carbonate, or the quicklime, (for it absorbs carbonic acid itself very slowly,) is soluble in the rain to which it is exposed, and rapidly dissolves out.

M. Artus proposes a method of preparation by which the process of silication is much favored; by which, it is said, a mortar may be prepared which becomes as hard as cement, does not crack in setting, and may even be used as a hydraulic cement under water. His process is the following: Take good slacked lime, and mix it with the utmost care with sand finely sifted. Mix the sand thus prepared with finely powdered quicklime, and stir the mixture thoroughly. During the process the mass heats, and may then be employed as mortar. Of course the mixture must be made just as it is to be used.

One part of good slacked lime was mixed with three parts of sand, and to this was added three-fourths of its weight of finely powdered quicklime. The mortar thus made was used in a foundation wall, and in four days had become so hard that a piece of sharp iron would not attack it. In two months it had become as hard as the stones of the wall. (*Ann. du Genie Civil, Zeitung des Ver. Deutsch, Eisenbahn-Verwalt.*)

Would it not be worth while to try this for laying the bricks of our chimnies, which are so rapidly destroyed and rendered dangerous by the gases from burning anthracite?

Detection of Adulteration of Oils.—We find, in the *Bulletín de la Société Industrielle de Mulhouse*, a communication from M. Nicklès, to which we call attention, as it may, when properly studied, be of importance in detecting the adulteration of oils, now so difficult to ascertain.

It appears that the sweet oil of almonds is almost always found adulterated by a cheaper material, known as the oil of apricots, and to detect this falsification M. Nicklès proposes the following mode: Take about 10 grammes of the suspected oil, (the gramme is about $15\frac{1}{2}$ grains,) and shake it with about $1\frac{1}{2}$ grammes of slacked lime, (in powder.) Heat it in a water bath, taking the precaution not to raise the heat above 100° C., (212° Fahr.) Filter while warm. If the oil contains as much as 1 per cent. of the impurity, a cloudiness will be seen as the filtrate cools, disappearing again on the renewal of the heat. By suffering the oil to cool to the ordinary temperature, this cloud may be separated by filtration, and will be found to be a species of emulsion, formed by the oil of apricots with the lime. It is fusible by the heat of the water bath, and is then a limpid liquid, lighter than water, and congealing by cold, soluble in warm oils, but separable by filtration when cold, soluble in sulphuret of carbon, decomposable by mineral acids, aided by a gentle heat.

M. Nicklès goes on to show that olive oil, (sweet oil,) colza oil, as well as the sweet oil of almonds, do not produce this emulsion with lime; while hemp seed, poppy, walnut, (English walnut,) and flax seed oils give it, more or less. Cotton seed oil gives very little, but castor oil a very thick, coagulum.

Now, as a great deal of the material which is sold here as olive oil is really little more than lard oil, it would be worth while to see whether this falsification could not be detected in this simple way.

M. Nicklès also calls attention to the unfitness of sweet almond oil for lubricating watch-work, for although when pure it produces no action upon the brass, yet it sooner or later hardens, never having been freed from its drying quality.

Lead Poisoning.—A somewhat curious, and certainly very interesting case of poisoning by lead has just occurred in the Walkill Valley, in New York State. A miller of that valley, renowned for the quality of his flour, and correspondingly pressed to furnish the supply demanded, had mended an old pair of stones by running metallic lead into the cavities. The consequences were fearful. Over two hundred cases of lead poison made their appearance among his customers, some of which were fatal, and some resulted in permanent paralysis of the limbs. It is said that the particles of lead could easily be detected by the microscope in the flour. It would also appear that this is the usual method of repairing worn mill stones. Of course, the processes of fermentation and baking of the flour convert the lead into the carbonate or white lead.

Is it not time that the millers were furnished with an available substitute for the coarse sandstone or conglomerate, which is still universally used in grinding flour, and which, by their irregular wear, give life to such methods of mending?

New Flying Ship.—We find, in the New York papers, the notice of a new flying apparatus, constructed by Dr. Solomon Andrews, which, we suppose and hope, is the one which was reported to be in process of construction by the U. S. government. Dr. Andrews' apparatus is an oblong ("lemon-shaped") balloon; along which, both at top and bottom, a deep groove is made by means of a stout leathern strap passing around it, and furnished with the requisite braces for slackening or tightening it. This is to serve as a keel to hold the vessel to her course. The method of progression is by elevating or depressing the forward end on the principle of a kite or a bird when sailing, and the inventor is doubtless right in his anticipation that in this way it may be made to go against the wind, provided it be not too violent. The preliminary trials do not seem to have been actually successful, although results were obtained which seem to have encouraged the inventor. The fault of the failures is laid upon the rudder. The great difficulty, we apprehend, will be found in the leeway which such a vessel must make with the wind abeam, an action against which the most powerful birds find it difficult and frequently impossible to sustain themselves.

We find, in the *Cosmos* of Paris, a curious statement, taken from a newspaper of Rouen, of the sudden appearance at Houlme (Seine-Inferieme) of a flying ship, which stopped for a supply of coal. The statement of the aëronauts was, that their boat was devised and constructed by Sir George Matthews of Darlington, England, who left that place on the 27th of March, accompanied by MM. Barckley and William Thompson, professors in the "School of Oxford." (The University?) First vis-

iting Scotland, they then steered to the north-east and crossed the North Sea in the direction of the island of Heligoland, (which is south of east from any point of Scotland,) over which they passed on the 29th, moving towards Hanover with the intention of going to St. Petersburg, but being baffled by heavy fogs (!) they changed their route, and, after various perigrinations over Germany, returned towards England, and arrived at Houlme on the 31st, where they stopped, at a height of 30 feet, for a supply of coal. The travelers refused to explain the construction of their machine, or to allow it to be examined, but the correspondent describes it as an elongated ellipsoid of very thin galvanized sheet iron, with several gas receivers, and driven by a small engine, (which the smell indicated to be an ether engine,) by means of two screws.

Coal-bricks.—Our English cousins are getting to be seriously anxious about the endurance of their coal-fields, which has been authoritatively pronounced to be a question, not of centuries, but of years; and a distinguished gentleman of our city, whose position gives him excellent opportunities of knowing, and whose capacity of judging gives great weight to his opinion, is said to have predicted that in a few generations our anthracite would be a luxury for the rich, and an impossibility for the arts. In view of such possibilities, economy becomes a duty, and we recommend to the notice of all interested a very elaborate memoir by M. Gruner upon the methods in use for utilizing the coal waste by conversion into bricks, by means of tar or other cheap materials. M. Gruner, after an introduction devoted to the history of these methods, proceeds to discuss the subject at large, describing the different forms of apparatus used, pointing out their merits and defects, and explaining the whole method of the process. The memoir is too long to be transferred to our pages, and, from its nature, cannot be condensed, but we recommend it to all who are disposed to look into the subject as being apparently an exhaustive treatise. It will be found in the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale* for October, 1865.

Cheap Electric Battery. By M. GERARDIN, Acad. of Sciences, Paris. —M. Gerardin proposes to obtain a battery of feeble tension, but considerable quantity and cheap, by substituting in the Bunsen battery chippings of wrought or cast iron in place of zinc. An iron plate in contact with them serves as a conductor; the exciting liquid is ordinary water. In the porous cell, the Bunsen carbon, made of gas coke pulverised and cemented by paraffine, by M. Carlier's process, is immersed in a solution of perchloride of iron, to which some aqua regia is added. This pile can be made of large dimensions; and the proposer states that large quantities of electricity can be obtained from it at a very small price.

Aurora Borealis.—M. E. Renou has collected and discussed all the available records of the appearance of this meteor, for the purpose of

developing, if possible, the period of its maximum and minimum occurrence. The yearly period is that established by Mairan, viz: two maxima near the equinoxes, of which the fall maximum is the principal; and two minima, corresponding to the solstices, that of the summer being the most marked. The secular period presents in Europe a well marked maximum, from 1716 to 1780, the period being probably about 196 years. In America, the period would seem to be alternate with that in Europe. It is to be remarked, that as the phenomenon appears to be almost continuous in higher northern latitudes, the periodicity would refer only to the extent to which the appearance is visible.—*Acad. of Sciences, Paris.*

Mortars for Marine Constructions.—M. Poirel called the attention of the Academy of Sciences of Paris, to the great importance of the question, "What mortars could be most safely employed for artificial blocks for the foundations of marine constructions?" He states, as the result of his own experience in constructions at Leghorn and at Algiers, that the only material upon which full reliance can be placed, is the pozzuolana from Rome, sifted through metallic bolters, and combined with fat lime slacked with two and a half times its weight of water. One part of this hydrate is mixed with two parts of pure pozzuolana, when the beton is to be immersed at once; or with one part of pozzuolana and one of sea-sand, where it can be dried before immersion. He states, that in regard to the difference of opinion between M. Vicat and M. Minard, as to the durability of betons thus made with Italian pozzuolana, experience has shown that M. Minard was correct in affirming this durability; and that the laboratory experiments of M. Vicat, by which it was shown that such materials could not withstand the action of the sulphate of magnesia which exists in sea-water, were inconclusive, because, in practice, the beton is protected by a calcareous deposit, which forms on its surfaces, and by the growth of sea-weed by which it is covered. He condemns the use of artificial Roman cement, whether of French or English origin, and predicts the rapid destruction of marine works constructed with them; and states that in certain works executed by him in Turkey, in 1847 and 1848, he used a natural pozzuolana from the Santorin Island, which have stood so far very well, although the experiment has not yet lasted long enough to be entirely reliable.

The Secular Acceleration of the Motion of the Moon.—La Place showed that the change of eccentricity of the earth's orbit must produce a corresponding acceleration in the moon's motion, and the amount of this change was calculated by him, by Plana, Damoiseau, and by Hansen, all in good accordance with each other, and all giving a value which agreed very well with ancient observations of eclipses. But Mr. Adams, in reviewing this subject, thought he found an error in the formulas, which reduced this acceleration about one-half, and his results having been confirmed by M. Delaunay and others, a vigorous controversy arose, which appears to be now finally settled in favor

of Mr. Adams and Delaunay, M. Hansen, the last eminent conservative, limping out of the matter in rather a lame manner. But the ancient eclipse observations must be satisfied, and the new co-efficient upsets our chronologies, and represents great admirals as sailing their ships on the sands of the Lybian Desert. Some other cause must, therefore, be looked for to give the additional six seconds per century of acceleration wanted, and fortunately it is in modern science that the scriptural maxim, "Seek and ye shall find," is infallibly fulfilled. M. Delaunay has consequently come upon the discovery that La Place was wrong in establishing the invariability of the earth's rotation on its axis; that, in fact, the moon, by raising the tides, and not doing it quickly enough, is constantly producing a friction on the bottom of the ocean, which is slowly but surely bringing the earth to rest. But M. Delaunay calculated without the geologists. As the earth, according to these, is continually shrinking, "like a roasted apple while it cools," the rotation ought to become more rapid, and these desirable six seconds be absorbed. So that we hail the new suggestion of M. Dufour, that these six seconds are due to the increase of mass of the earth by the showers of meteors upon it, and he shows that, supposing the average density of these meteors to be two-thirds of that of the earth, (3·67,) 110 cubic kilometers, or about 264 cubic miles per year, would be required, which, as M. Dufour remarks, is nothing impossible. M. Dufour's theory has also the advantage of showing that the earth is increasing in importance in the system, which is flattering to our vanity.

Since writing the above, Mr. Airy, the royal astronomer of Great Britain, fully endorses M. Delaunay's views, and his endorsement will carry the more weight since it is evident that it was only towards the close of the investigation that he was led to concur, his first verdict being evidently "not proved." Prof. Gurld also writes to remind Mr. Airy that the same result was reached by Mr. Ferrel, in a paper published in the *Astronomical Journal*, (Boston,) in 1853, where it was shown that the effect of the moon, in one century, would be a retardation of the earth's equator of about 37·5 miles in a century, and that, adding the effect of the solar tide, the total retardation should be about 44·5 miles, which retardation would be equivalent to an apparent acceleration of the moon's motion of 84″ per century. And, in conclusion, the author calculates that, to counteract this acceleration, (nothing like which had then been observed,) "there is required a contraction of about 1·017 feet in the earth's radius during a century, upon the hypothesis of an equal contraction throughout the mass."

Water-proof Packing Paper.—The following is a German recipe: Dissolve 680·4 grammes (about 1·82 lb.) of white soap in a quart of water. In another quart of water, dissolve 1·82 oz., troy, of gum arabic, and 5·5 ozs. glue. Mix the two solutions, warm them, and soak the paper in the liquid. Pass it between rollers, or simply hang it up to drip, and then only at a gentle temperature.

Chlorophylle.—M. Fremy, who, some time ago, succeeded in decomposing the green coloring matter of leaves into a yellow and a blue coloring matter, has carried his investigations further, and shows that the true matter is an acid combining with bases, while the yellow is neutral. The combination of the two suggests analogy with fats which are also combinations of a peculiar organic acid with glycerine, a body which, although playing the part of a base in this combination, is neutral in its general behavior. M. Fremy, however, does not believe that the chlorophylle, in its living condition, is a compound of this nature, but considers it as a very unstable body, breaking up, by the action of the reagents, into these two substances which he has succeeded in obtaining. As we learn that the blue (phyllocyanic acid) easily modifies its color by dilution, or by reaction, assuming olive-green, purple, or bright red tints, the splendid coloring of our autumn forests becomes easy of explanation.

Substitute for the Nicol's Prism.—MM. Hartnack and Prazmowski give, in the *Annales de Chémié et de Physique*, their investigation of the Nicol's prism, and their method of remedying its defects, which are the limited field of vision and the inconvenient length. They propose to cut a prism of calcspar, so that the diagonal section shall be perpendicular to the optical axis of the spar, and cement the parts by linseed oil. This prism is shorter than the Nicol in the ratio of 2 to 3, and may be used as an analyzer, with a compound microscope, without limiting the field and without inconvenience to the observer.

New Magnets.—Mr. Griess has observed that the turnings of iron and steel, and especially those long shavings which come from the lathe, are strongly magnetic. Their magnetism is permanent. The spiral turnings of wrought iron show this remarkable property in the highest degree. He finds that the end at which the tool commenced is a south pole, the other extremity being, of course, the north. The direction of the spiral is also said to exercise an influence on the intensity of the magnetism produced.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, June 20, 1866.

The meeting was called to order with the Vice-President, Professor Fairman Rogers, in the chair. The minutes of the last meeting were read and approved.

The Board of Managers presented their minutes, and reported that at their meeting on the 13th inst. they received donations to the library from the Royal Astronomical Society, the Chemical Society, the Institute of Actuaries, the Statistical Society, and the Society of Arts, London; La Société d'Encouragement pour l'Industrie Nationale, Paris, France; the Canadian Institute, Toronto, Canada; the Chamber of Commerce, New York; the Managers of the State Luna-

tic Asylum, Utica, New York; Thomas Gaffield, Boston, Massachusetts; the Odd Fellows' Library Association, San Francisco, California; and Edward Parrish, Esq., Prof. John F. Frazer, Thomas P. James, Esq., and John W. Nystrom, Esq., Philadelphia.

Four gentlemen were elected members of the Institute.

The various Standing Committees reported their minutes.

The Special Committee on Experiments in Steam Expansion reported progress.

The monthly Report of the Resident Secretary on Novelties in Science and Art was then read as follows:

Secretary's Report.

Engineering Works.—Water Supply of Paris.—We find an excellent article upon the above subject in the *Practical Mechanics' Journal* for May, from which it appears that up to the present time the supply of this very important article has always been deficient, and, though constantly increasing, has never caught up with the increasing demand. Thus, in 1550 it was 44,020 gallons per day, or less than one-fifth gallon per inhabitant. Several changes were made during the next century, by which the quantity was increased to 396,180 gallons per day, or ·66 gallons per inhabitant, an amount, however, absurdly inadequate, especially when it is remembered that this included ornamental fountains and the like. In 1782 the supply was increased by the works at Chaillot, which, however, drew their material from under the very sewers, and in the drought of 1856, when this afforded five-sixths of the whole supply to the city, it contained, as was proved by analysis, one-forty-fourth of sewage water.

These works raised the supply to 1,760,800 gallons per day, or 3·08 gallons per inhabitant.

In 1822 the canal of the Ourcq, 60 miles long, and used also for purposes of navigation, was finished, and, with seven private works pumping from the Seine, together with the artesian wells of Grenelle and Passy, raised the supply to 46,000,900 gallons per day, which includes, however, the quantity required by the extensive ornamental water-works at the Bois de Boulogne, &c., and was found very inadequate, especially during the hot weather.

In October, 1865, a fresh supply of pure and excellent water was brought in by an aqueduct from the Dhuis, amounting to 5,722,600 gallons per day. By this and the increased development of the old sources, it is estimated that 75,714,400 gallons per day may be obtained, which will cover the existing demands, which are for 70,-211,900 gallons, while works are shortly to be undertaken for carrying the waters of the Vanne to reservoirs at Montrouge. The supply will then cover the anticipated increase in demand, (about 22,230,000 gallons,) and will amount to 18 gallons of spring water per inhabitant, with 26,412,000 gallons for flushing sewers, &c.

To receive the waters of the Dhuis, enormous crypts have been constructed at Menilmontant, capable of containing nearly 30,000,000 gallons. The first of these constructed has a capacity of 22,010,000

gallons. Its arches are 18·4 feet high, supported by 590 piers, 19·7 feet apart. It is to be covered with sod, and the water flows into it over a mass of rock-work, and amid beautiful shrubbery. It was built upon marly ground, which necessitated deep foundations, which suggested the idea of excavating under it for a second reservoir. This has been accomplished, and the lower crypt has a capacity of 6,823,-100 gallons. Its arches are supported by 240 piers of the most massive structure. During the late visit of the municipal authorities, before the water was admitted, these cyclopean vaults were illuminated by the electric light, with the most striking effect. The cost of these reservoirs is about $720,000.

Hydraulic Lift Graving Docks.—A paper was read on this subject before the London Institution of Civil Engineers by Mr. Edwin Clark. The vessel to be docked in this manner is floated into the lifting pit, at the bottom of which has been placed a large iron pontoon, properly connected with a series of hydraulic lifts surrounding the pit. By these the pontoon and ship are raised until the water has run out of the former through appropriate valves, when the whole will float with a draft of but 3 or 4 feet, and may be moored in a shallow water space adjoining the lift, and wherever most convenient for work.

Such a plan was adopted by the Thames Graving Dock Company in their works adjacent to the Victoria Docks. The lifting pit was 27 feet deep, 60 feet wide, by 400 feet in length. Sixteen presses were placed on each side, with iron girders, 65 feet long, connecting them in pairs across the pit. Attached to this were 16 acres of shallow water space, 6 feet deep, for floating the pontoons, &c., when raised. This was divided into 8 pontoon berths by jetties for workshops. Total cost $127,640. Number of vessels lifted last year 1055. Aggregate tonnage 712,380 tons.

A Large Iron Suspension Bridge is about to be constructed over the Moldan at Prague, on Mr. Ordishe's rigid principle. It will consist of three spans, the centre one 476 feet long, the others 172 feet. The roadway consists of two wrought iron web girders, 6 feet 10 inches deep, with T-irons along the middle, to give lateral stiffness. The web will be punched out in an ornamental pattern above the actual roadway. These girders are supported by a series of straight inclined bars, which are themselves held in their straight position by guys from curved chains or wire ropes above.

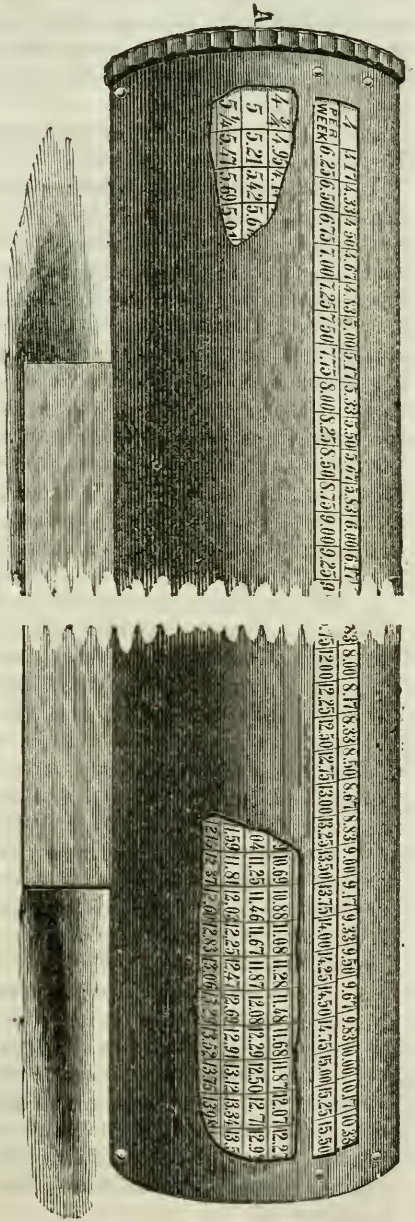
An iron girder bridge, 1524 feet long, designed by James Laurie of Hartford, Conn., has lately been completed over the Connecticut River, on the Hartford and New Haven Railroad. This structure was erected to replace one of wood, and was substituted piece-meal for the latter, while that was in use, with trains running on the average every 30 minutes during the day, and with only a single track.

The iron work was constructed by Wm. Fairbairn & Co., Manchester, and the London Engineering and Iron Ship-building Co., the press of work for the government at that time preventing any of the American manufacturers from undertaking the contract. There are twelve spans of 88½ feet, and one of 177 feet.

There were then exhibited various models and improvements in apparatus, as follows:

The improved calculator by C. W. Peale.

By the use of this instrument the various causes of error heretofore existing in the making-up of pay-rolls are entirely avoided. It consists of a cylinder, (see cut,) on the surface of which is arranged a calculated table; the left-hand column contains the number of days and fractions of days to be calculated, namely, 1, $1\frac{1}{4}$, $1\frac{1}{2}$ days, and so on, for any number of days, to suit, for weekly, semi-monthly, and monthly payments. This cylinder is enclosed in a zinc case, and revolves therein on pins having a bearing in the ends of the case. It is easily moved by a milled head at the left end, and the whole is neatly mounted on a walnut base. Running nearly the entire length of the case is an opening sufficiently wide to expose but one row of figures at a time. Immediately below this opening is placed, on the outside of the case, a row of figures denoting the several rates of wages, from the lowest to the highest ordinarily paid. The operation of this instrument can be readily understood by presenting an example, as follows:



To find the amount of wages necessary to be paid for $9\frac{3}{4}$ days at the rate of $12·75 per week, or $2·12$\frac{1}{2}$ per day, turn the cylinder by means of the milled head at the left end, until the figures $9\frac{3}{4}$, on the left-hand column, appear to view; then above the figures $12·75, denoting the rate of wages, on the outside of the case, will be found $20·72, which is the amount to be paid.

The discount and interest calculator, also invented by C. W. Peale.

This instrument consists of a shallow box, 11 by 6½ inches, provided with a band, passing over rollers within it; upon this band is the table of the amounts of discounts, also the days to run. Upon four slides, which move backwards and forwards under the cover of the box, are marked divisions, corresponding to units, tens, hundreds, and thousands, which, when set at any division, expose, through openings in the centre of the box, the discount corresponding to the time at the top of the table.

An improvement in traction engines and locomotives, by Theodore Krausch, was then exhibited.

In this, the object is to increase the adhesion of the locomotive during any change in velocity by throwing part of the weight of the preceding or following trucks or cars upon the engine. To accomplish this the engine is connected with the truck or car by a long bar or lever which rests on a rounded block as a fulcrum near the end, which is attached to the frame of the locomotive by a vertical link; the other end of this bar is attached to the truck. In its normal position the bar is horizontal and the link vertical, but any pull or push upon the bar will cause the link to incline, so bringing down that end of the lever and raising the other, which, being attached to the car or truck, will tend to lift it, so throwing its weight upon the engine. By this means at starting or on up grades when the cars pull, or in breaking up or down grades where they push upon the engine, this action gives the latter greater adhesion to the rails and will enable a light engine to do the work of a heavy one just where this is required.

A fruit drying house, by Jasper Billings.

A water door for puddling and other furnaces.

A gas purchase-tongs, by Richard Cox. This differs from the ordinary tool in two respects: First, it has but one handle; and second, it is adjustible in its grip, so that two tongs would suffice for all sizes of pipe in general use. The lower or concave jaw of this tool is short, and terminates above in a swiveled nut, through which passes the long handle of the other jaw, whose end or griping extremity is connected by a revolving joint with the rest of the handle, so that this last can turn in the nut of the lower jaw, changing the distance of the two without otherwise disturbing the upper jaw, which is prevented from turning round by a projection, which fits in a longitudinal slot of the lower jaw.

Utilization of Coal Waste.—In the October number of the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, we find an excellent paper on the various plans which have been adopted for consolidating coal dust and like "waste," which forms so large a part of the whole material extracted from the mine.

The history of inventions and improvements in this process is given with great completeness, from an early period, and the practical results of various plans are given with precision.

Many plans for consolidating coal dust without cement have been

tried, and the accomplishment of this end is very desirable, but has not as yet been attained. Thus, the bricks prepared according to the plan of Evrard, by mere pressure, burn well, but will not bear transportation.

The process of Bessemer, in which the coal is heated almost to redness and then compressed, is too expensive and wasteful, while in that of M. Baroilier, where the coal is compressed first and baked afterwards, the cost for handling is considerable, and the "plant" required very expensive.

Among cements, the cheapest is potter's clay, the most usual, coal tar and its derivative solid or fluid pitch.

The coal selected for treatment should be friable, semi-bituminous, or a mixture of "hard" and soft, of short flame, well washed from earthy matter. As little cement as possible should be used, and this result may be best secured by thorough mixture and heating. The pressure applied should reach about 1 ton to 1½ tons per square inch, and the bricks should be thin. Thus a brick containing 18 to 20 lbs. should be about 4 inches thick. To effect the compression on the large scale, the best machine is that of Révoillier, in which a moving circular table carrying moulds is combined with an hydraulic press acting quickly, by means of a reservoir under pressure. Working on a small scale, the machine of MM. David and Mazeline, which acts by tangential wheels, will be efficient.

In France, 18 or 20 establishments are engaged in this manufacture, and produce yearly about 500,000 tons. In Belgium seven manufactories produce 400,000 tons.

In the above-mentioned journal for November we also notice an excellent article on the subject of steam paving machines, from which it appears that engines running on heavy rollers, and self-moving, which execute their work by simply going over the ground, are and have been employed with marked economy and success in the various concrete and macadamized pavements of Paris.

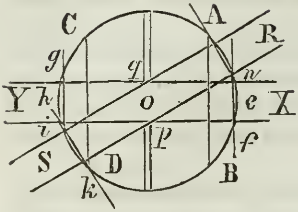
PHYSICS.—The New Photographic Lens invented by Joseph Zentmayer of this city, is of the greatest interest, not only in a practical sense, because it is a most excellent and efficient instrument, which can be constructed at less than half the cost of any other equally good combination, and possesses other like advantages of lightness, compactness, adjustability, &c., which will be more fully stated hereafter; but in a scientific point of view also, because it involves new principles and new applications of optical laws.

The theory of this lens may be best explained by the following progressive illustrations:

Let A B and C D represent two plano-convex lenses exactly alike in every respect, so placed that their outer surfaces form parts of the imaginary sphere A C D B, and with a small opening $p\,q$ in a central diaphragm. Neglecting for a moment the bending of rays by refraction, we see that the only rays which can pass the diaphragm are those which come normally upon the outer surface, as X Y and R S. Supposing sections to be made in the direction of the chords $n\,f$, $g\,i$,

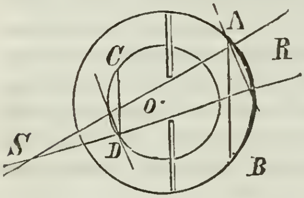
we see that the ray X Y will be subjected to the action of two small lenses, *n e f*, *g h i*, (limited by the size of the diaphragm,) and two blocks of parallel glass. The aberration, spherical and chromatic, may therefore be regarded as that only which is due to two such extremely minute lenses.

Fig. 1.



Turning again to the ray R S, and supposing similar sections, A *n* and *i k*, we have the ray again acted upon by two small lenses like the first, but in this case traversing two prisms. As, however, these are exactly equal and opposite, they will correct each other, and the aberration in this, as in the former case, will be such only as is due to the two small lenses. We are here speaking, it must be remembered, only with the purpose of explaining a general principle, and without regard to accuracies of detail which would confuse the subject, as we think.

Fig. 2.

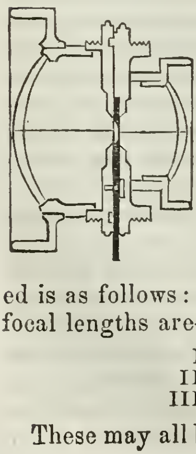


In this preliminary illustration we have made no account of the *deflection* produced by the first prism, nor of the *concentration* due to the little lens. To meet the first, the diaphragm is moved a little forward from the centre, O, and for the second, in place of the large lens, C D, a smaller one of shorter radius is so placed that its outer surface is practically concentric with that of A B. (See Fig. 2.)

The converged ray thus finds in C D an equivalent opposite prism to that it traversed in A B, and is only subject to the aberrations due to the two small lenses, now of *unequal* curve.

Thus far the general principle by which a lens of very small aberration may be made with only one kind of glass, or without *correction*, has been treated.

Fig. 3.



Such a combination, however, as that last described would be of little value because of its very short focus and want of flatness in field. To remedy these difficulties, in place of plano-convex, meniscus lenses are used, (as shown in Fig. 3,) whose inner curves are to their outer ones as 13 is to 12. The curves of the two lenses are to each other as 3 to 2 in all cases. Any variety of combinations and series of focal lengths might be constructed on the above principle, but the plan adopted is as follows: The most complete set consists of six lenses, whose focal lengths are—

I.	5·333 inches.	IV.	18· inches.
II.	8· "	V.	27· "
III.	12· "	VI.	40·5 "

These may all be successively arranged in the same mounting, giving

combinations with focal lengths and circular fields at 90° as follows:

Lenses I. and II.	give a focal length of		3·55	inches and	field	7	inches	diameter.
" II. " III.	"	"	5·33	"	"	$10\frac{1}{2}$	"	"
" III. " IV.	"	"	8·	"	"	16	"	"
" IV. " V.	"	"	12·	"	"	24	"	"
" V. " VI.	"	"	18·	"	"	36	"	"

Thus, with six lenses and one mounting, five different instruments may be successively adjusted in as many minutes, the mounting being so arranged as to fit into the camera either way. To pass from one focal length to the next longer in the series, it is only necessary to take out the smaller lens and put in its place the second size above. Thus, to change 8 inches into 12, lens No. III. is replaced by No. V., and the mounting reversed. A little shutter, close to the central diaphragm, serves for "exposing" in place of a cap, and a diaphragm plate is arranged with three holes for each combination, a large one for focusing, a middle size for quick work, and a small one for fine and difficult work, for it is one of the merits of this lens that a large stop may be used for focusing, and a small one thrown in for the exposure with not only good but the very best effect.

In these lenses the visual and actinic focii appear to coincide, so that no adjustment after focusing is needed. The field is very equally illuminated, because no doubt, as will be seen from Fig. 1, the marginal rays, as well as the central, are normal to the first surface, and do not lose unequally by reflection. The depth of focus is most remarkable, and for quickness of work surpasses that of any like instrument. Excellent views have been taken in 15 seconds on a bright, and 30 seconds on a dark day.

Mr. Coleman Sellers here remarked as follows:

There are some facts in connexion with the history of this invention which I think will be of interest to those present. Some two years since I had many conversations with Mr. Zentmayer on the subject of the globe lens, and of such lenses as were constructed in a similar manner, and, at that time, he expressed to me his opinion that in such a combination, whose outer surface was a sphere, and which had a central stop, all correction by use of two kinds of glass in the separate lenses was unnecessary, and that a combination might be constructed, consisting of two deep meniscus lenses, which would possess all, and more than all, the merits of the globe lens, and be in addition, much cheaper, lighter, and characterized by many other peculiar advantages.

The theoretical view of the subject, and the proposed structure of the lens, Mr. Zentmayer explained to me at that time by drawings which correspond with those shown this evening, and with the instrument itself, as you now see it before you. It is a matter of peculiar interest and redounding to the credit of the inventor that this instrument was thus the result, not of chance discovery or accidental observation, but of thorough and accurate scientific knowledge judiciously applied to the development of a definite object.

At the time already mentioned, I strongly urged Mr. Zentmayer to construct a lens according to his plan, and secure a patent on the

same, and, after such delay as extensive and active business relations rendered unavoidable, this was done, and the patent, in fact, ordered to issue, when, before the papers were posted, though actually directed, an application was received from Mr. Steinheil, and an "interference" declared by the authorities of the Patent Office. On trial, however, Mr. Zentmayer conclusively proved "priority," and his patent was finally secured. The resemblance between these combinations of Zentmayer and of Steinheil is confined, however, to the fact that both use two meniscus lenses of one kind of glass and a central stop. While the principles on which they are based and their modes of construction are essentially different. Thus, in Steinheil's combination, the outer curves of the lenses are not concentric with each other, and, with the diaphragm and the rays which pass the latter, are not normal to the surface; the two lenses used are not of different curves, nor do they admit of any change by substitution. The stop used is much smaller, and the time of exposure therefore greater, and, what is most important, there is no coincidence of the visual and actinic focii, and adjustment after focusing is therefore required.

The diagrams required to illustrate the preceding description were drawn upon glass with Japanese india ink, and thrown upon a screen 12 feet square, by a large lantern, with so much distinctness, that two large gas burners in front of the screen, burning at full head, did not sensibly impair the effect and allowed the Secretary to refer to his notes with facility, and to point out the various parts, with a rod, as would be done were the image an actual drawing upon the screen.

A Series of Drawings on Glass, illustrating the account of a remarkable *sun-spot* lately published by Mr. Howlett, were then shown by projection in the same manner. These drawings were made in a manner suggested by Mr. Joseph Wilson, C. E., by first washing on thin india ink and then working over with thick ink in a dry brush, and, lastly, going over certain parts by stippling and fine scratching with a steel point. The pictures so obtained were remarkably delicate and accurate.

A Series of large Photographs (6 inches in diameter) **of Microscopic Objects**, made by Dr. Robert Griffith with lenses of ordinary description, but provided with a central diaphragm, were then projected in like manner and showed admirable flatness of field and sharpness of definition.

An Arrangement of Glass Tanks, by which many physical and chemical experiments may be exhibited on a large scale, with the lantern, was then shown. To construct these, all that is required is a few pieces of moderately thick sheet glass, some strips of thick rubber $\frac{1}{2}$ inch to 1 inch, and some simple clamps. The strip of rubber is bent so as to form three sides of a rectangle, being cut partly through at the corners, and a plate of glass being placed on each side, the clamps are adjusted so as to hold all together. The tanks thus prepared are generally about $\frac{1}{2}$ inch thick inside, and 4 by 6 inches in the other direction. The backs of the clamps being flat, the tank stands very well on the two lower ones. These tanks are very easily made, cost

little, are readily cleaned, and admit of numerous modifications. The simple tank answers to show in the lantern the action on light of variously refracting liquids when mingling, and their motions produced by differences in density with a very impressive effect. Thus, a solution of muriate of tin, run by a pipette into a tank of water, will develop on the screen something suggestive of a submarine volcano in full eruption.

The same arrangement serves to exhibit many chemical reactions with striking characteristics. Thus, a little sulphate of copper being dissolved in the tank, and weak ammonia being run in, a mass of black clouds are first seen rolling and tumbling upon the screen, then gradually melting away into a clear sky-blue.

By placing one solution in the tank, and another in a test-tube plunged therein, the colors of both before combination may be noted; then, by upsetting the test-tube with a glass rod, the reaction and consequent change of color is beautifully displayed. Even delicate experiments conducted in test-tubes may thus be exhibited to large audiences by plunging the tubes in one of these tanks containing clear water when the refracting action of the round tube is corrected.

The larger sort of aquatic insects and small fish make very interesting magic lantern objects in these tanks. With a wet cork-borer, holes may be readily pierced in the rubber sides of these tanks and glass tubes introduced, by which, connexions being made for overflow, outlet, and fresh water supply, a series of changes may be conducted in the same tank with great rapidity and ease without removing it. To use these tanks with the ordinary lantern it is only necessary to arrange a separate support for the object-glass, so as to leave a clear space in front of the condensers where a block or little shelf to support the tanks may be placed. The decomposition of water by galvanic action, formation of metallic crystalline vegetation by the same, &c., may be readily shown. These various arrangements have been used by the Secretary, during the last winter, with the most satisfactory results.

The Yellow Light from Soda Glass mentioned in the last report, is found by the Secretary to answer very well, when used in the gas polariscope, to show the vast increase in number of rings developed by sections of crystals when monochromatic is substituted for white light. The adjustments are first made with the lime cylinder, the glass is then substituted and slightly lowered, when, in place of the six or seven rings before seen, we find a great number covering the whole screen.

The Spectrum of Sirius, according to the observations of Father Secchi, shows between the extreme red and the line A a number (28) of equidistant bands.

The Spectrum of α Orionis has lately lost a group of fine lines in the orange near the yellow. This corresponds with the change of color in this star, which varies very irregularly both in the color and intensity of its light.

The great Nebula in Orion, lately proved by spectrum analysis

to be gaseous, appears, from some observations by Mr. T. W. Webb, to give evidence of change in form.

It is worthy of note that all the drawings of this body, made by different observers, have been decidedly unlike. (See Mo. Notices of Roy. Astr. Soc., 1866, page 208.)

Enlargements of Professor Piazzi Smyth's photographs of the pyramids and their environs, from original negatives one inch square, were exhibited by projection on the screen at a late meeting of the Edinburgh Photographic Society.

A Kaleidoscope for the Magic Lantern, presented by James Queen & Co., was exhibited with various objects and found to give a field of remarkably even illumination and beautiful effect.

A new Galvanic Battery is proposed by M. Gerardin. The outer cell is to be filled with iron turnings having a strip of sheet iron for a pole, the liquid, water. The inner cell to contain a carbon element plunged in a mixture of perchloride of iron and aqua-regia. (*Comptes Rendus*, page 700.) We do not see how the connexion between the various pieces of iron turnings is to be maintained. Where amalgamated zinc is used, this is accomplished by an excess of mercury.

Transparent Paper may be prepared by the use of copal varnish diluted with its own bulk of turpentine and well filtered through cotton. The paper should be stretched on a frame and varnished on both sides while held near a hot iron plate, then dried for a week.

A Process for Coating Iron with Copper is given in the *Journal of the Society of Arts*, with many absurd mistakes. A correct account, *i. e.*, the original report by M. Payen, will be found in the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale.*

CHEMISTRY.—The Removal of Hypo-sulphite of Soda from photographic prints by placing them, for a few moments, in water containing a small per centage of deutoxide of hydrogen, is stated by the editor of the *British Journal of Photography* to be accomplished with great ease and completeness, and thus to remove the danger of deterioration by which these pictures are now beset.

Mr. Coleman Sellers remarked that he regarded the fading of prints, not as the result of hypo-sulphite of soda left in the paper, for he had known prints, purposely charged with this salt, which absolutely refused to fade, but as occasioned by sulphide of silver. This salt also might be removed by the oxygenated water, but as yet this was a matter only of theory which time must settle.

It is stated on the authority of Schonbein that $H\,O_2$ may be prepared by shaking in a bottle with air, powder of amalgamated zinc, and water.

The Defecation of Sugar by hydrofluoric acid, which is afterwards removed by lime, has been tried on the large scale with good effect at the Fridens-Aw factory, as is stated in the *Journal of the Society of Arts.*

A new Filter for River Water, which is stated to remove the soluble as well as insoluble impurities, is stated by Mr. T. Spencer to be found in a mixture of oxide of iron and carbon. This may be best prepared by heating magnetic oxide or red oligist with wood saw-dust.

The *Medical Times* suggests the addition of a little permanganate of potash, before filtering to oxidize organic matter.

In the *Comptes Rendus* we find a note by M. Tellier on the manufacture of methylic ether and its application to the production of cold. When the committee, to whom this matter has been referred, make their report, we shall know something about the curious complication of blunders cited under the head of "Freezing Machines" in last month's report.

Platinum may be purified and also rendered more malleable by heating with double chloride of magnesium and ammonium.

This same metal is deposited so as to resist the solvent action of hot sulphuric acid by a new process carried on by J. B. Thompson of Manchester, England. M. Scheurer-Kestner of Thann, found that each 1000 kilo. (2204 lbs.) of acid carried away about 2 grms. (30·8 grains) of platinum in the ordinary stills, and as much as 5 grms. (77·2 grains) if much nitric acid was present. A little sulphate of ammonia added to the acid prevented this waste, and platinum containing iridium suffered less than the pure metal.

An Amalgam of Magnesium may be formed if the mercury is heated, and will oxidize with wonderful rapidity, decomposing cold water with copious evolution of hydrogen, even when the amount of magnesium present is but a small per centage.

Bichromate of ammonia heated in the air undergoes a slow combustion, and is converted into a largely increased bulk of sesquioxide of chromium, having the shape and color of green tea leaves. The experiment is a very striking one. Mr. Charles Bullock has prepared some of this salt for this evening, by decomposing the chromate of lead with sulphuric acid carefully added, and, after removal of the insoluble sulphate of lead, neutralizing half the solution with aqua ammonia and adding the rest.

A letter from General Totten, on the subject of a Government Bureau on Mechanical Investigation and Experiment, was read and referred to a Committee consisting of Professor Fairman Rogers and Messrs. Henry G. Morris, William J. Horstmann, James S. Whitney, and J. V. Merrick.

At the conclusion of the Secretary's Report, Mr. John W. Nystrom made the following remarks:

At the last meeting of the Institute, the Secretary, Prof. Morton, stated in his Report on Novelties in Science and Arts that "the analysis of the Red Sea water lately made by MM. Robinet and Lefort, shows its identity with ordinary ocean water, and difference from that of the Dead Sea, thus disproving the supposed connexion of these by any subterranean communication."

It has evidently been supposed that the water would flow from the Dead Sea to the Red Sea, but how can that be possible, when we know that the surface of the former is some 1312 feet, or a quarter of a mile, below that of the latter?

There is one way of explaining the possibility of such water-flow, namely, by the difference of the specific gravity of the waters in the two seas, which is about 20 per cent.

A column of salt water of specific gravity 1·20 in the Dead Sea, of five times 1312 = 6560 feet = $1\frac{1}{4}$ miles, would balance a column of fresh water in the Red Sea equal to six times 1312 = $1\frac{1}{2}$ miles in height. Adding some depth to the column for head of flow, we have the operation possible, but the question is how the water can become fresh at the bottom of the columns?

It is possible, and even probable, that the salt water is distilled by volcanic heat in some cavities at the bottom of the Dead Sea, from which the fresh water is conveyed through some subterraneous channel to the Red Sea, or some other place. If there exist such a subterraneous conveyance, it cannot be an open free space conveying salt water which could not flow above the level of the Dead Sea, and if salt water was continually flowing out and fresh in, the saltness of the water in the sea could not remain permanent, but would soon become fresh and ultimately melt away the salt banks about the city of Sodom.

The subterraneous communication is likely very irregular, through hundreds of miles of strata of gravel and different kinds of minerals, in which the water would be so thoroughly filtered and rejuvinated, that it could not likely be recognized as water from the Dead Sea, even if taken at the very opening where it may enter the Red Sea.

I have made some calculations of the quantity of fresh water flowing into the Dead Sea in the dry season, and found it to amount to a thickness ($\frac{3}{16}$) three-sixteenths of an inch on the surface, 360 square miles, in twenty-four hours, which would be the amount of evaporation if there is no subterraneous discharge. In the rainy season, the water rises some 15 feet, which, by the before-mentioned rate of evaporation, would require a time of two years and a half to bring the level of the sea down to that in the dry season, and that even without the supply from the river Jordan, whilst the water falls to the ordinary level in some three months, in the coldest season of the year.

This fact seems to indicate the existence of a subterraneous discharge from the Dead Sea.

The supposition that the water in the Dead Sea would become fresh by fresh water flowing into, and salt out of it, is contradicted by the case of the Black Sea, where only fresh water is supplied, and salt water discharged through the Bosphorus into the Mediterranean. The quantity of salt passing through at Constantinople amounts to some 60,000 tons for every twenty-four hours, showing what an immense salt manufactory there must be in the Black Sea, and consumption of the same material in the Mediterranean.

The salt passing through the Gibraltar Straits into the Mediterranean amounts to one million and a half of tons per every twenty-four hours, which would be a chunk of solid salt as large as eight times the size of the Continental Hotel. I am unable to account for the manner in which this enormous quantity of salt is disposed of in the Mediterranean. Some of it may be carried off through some subterraneous channel into the Red Sea.

The meeting was then, on motion, adjourned.

Henry Morton, *Secretary.*

A Comparison of some of the Meteorological Phenomena of May, 1866, *with those of* May, 1865, *and of the same month for* FIFTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By Prof. J. A. Kirkpatrick, of the Central High School.

	May, 1866.	May, 1865.	May, for 15 years.
Thermometer—Highest—degree, .	84·00°	84·00°	90·00°
" date, .	13th.	17th.	7, '60; 23, '63.
Warmest day—mean,	70·17	75·50	79·83
" " date,	27th.	17th.	23d, '63.
Lowest—degree, .	44·00	46·00	35·00
" date, .	3d.	1st, 2d, 12th.	7th, '54.
Coldest day—mean,	50·33	50·50	40·00
" " date, .	3d.	1st.	3d, '61.
Mean daily oscillation,	16·06	13·81	16·93
" " range, .	5·65	6·60	5·58
Means at 7 A. M., .	56·71	59·87	58·53
" 2 P. M., .	67·73	68·91	69·71
" 9 P. M., .	60·10	61·39	61·47
" for the month,	61·51	63·39	63·24
Barometer—Highest—inches, .	29·940 ins.	30·147 ins.	30·338 ins.
" date, . .	8th.	15th.	4th, '52.
Greatest mean daily press.	29·901	30·120	30·273
" " date, .	7th.	15th.	5th, '52.
Lowest—inches, . .	29·156	29·405	29·096
" date, . .	28th.	22d.	27th, '61.
Least mean daily press.,	29·277	29·447	29·243
" " date, .	27th.	22d.	27th, '61.
Mean daily range, .	0·131	0·126	0·121
Means at 7 A. M., .	29 633	29·742	29·795
" 2 P. M., .	29·598	29·708	29·759
" 9 P. M., .	29·628	29·740	29·785
" for the month, .	29·620	29·730	29·779
Force of Vapor—Greatest—inches,	0·694 in.	0·683 in.	0·771 in.
" date, .	27th.	20th.	14th, '54.
Least—inches, .	·128	·143	·069
" date, .	3d.	3d.	2d, '61.
Means at 7 A. M., .	·310	·380	·356
" 2 P. M., .	·324	·389	·372
" 9 P. M., .	·334	·402	·379
" for the month,	·323	·390	·369
Relative Humidity—Greatest—per ct.,	93·0 per ct.	95·0 per ct.	100 per ct.
" date,	17th.	8th.	often.
Least—per ct.,	25·0	24·0	16·0
" date, .	24th.	3d.	5th, '55.
Means at 7 A. M.,	64·1	71·7	70·9
" 2 P. M.,	46·7	54·9	51·2
" 9 P. M.,	62·7	72·0	68·3
" for the month	57·8	66·2	63·5
Clouds—Number of clear days,* .	11	5	10·1
" cloudy days, .	20	26	20·9
Means of sky cov'd at 7 A. M.,	45·1 per ct.	76·1 per ct.	58·6 per ct.
" " " 2 P. M.,	64·2	69·4	61·1
" " " 9 P. M.,	55·2	54·5	47·6
" " for the month	54·8	66·6	55·8
Rain—Amount, ...	4·633 ins.	7·692 ins.	4·816 ins.
No. of days on which rain fell, .	9	13	12·5
Prevailing Winds—Times in 1000,	s77°14′w ·333	s74°17′w ·190	n82°35′w ·122

* Sky one-third or less covered at the hours of observation.

A Comparison of some of the Meteorological Phenomena of the SPRING *of* 1866, *with that of* 1865, *and of the same Season for* FIFTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A KIRKPATRICK, of the Central High School.

	Spring, 1866.	Spring, 1865.	Spring, for 15 years.
Thermometer—Highest—degree,	84·00°	84·00°	90·00°
" date,	May 13th.	May 17th.	May 7, '60; 23, '63.
Warmest day—Mean,	73·17	75 50	79·83
" " date,	Ap. 21st.	May 17th.	May 23d, '60
Lowest—degree,	18·00	24·00	4·00
" date,	Mar. 26th.	Mar. 11th.	Mar. 10, '56
Coldest day—Mean,	28·50	31·67	11·50
" date,	Mar. 26th.	Mar. 11th.	Mar. 10, '56
Mean daily oscillation,	14·69	14·04	15·96
" " range,	6·37	6·44	6·00
Means at 7 A. M.,	48·06	51·05	46·88
" 2 P. M.,	58·15	61·11	58·10
" 9 P. M.,	51·92	54 01	50·65
" for the Spring,	52 71	55 39	51·88
Barometer—Highest—Inches,	30·252 ins.	30·265 ins.	30·522 ins.
" date,	Ap. 17th.	Ap. 9th.	Mar. 3d, '52
Greatest mean daily press.	30·203	30·208	30·458
" date,	Ap. 17th.	Ap. 9th.	Ap. 3d, '54
Lowest—Inches,	28·820	29·185	28·820
" date,	Ap. 23d.	Mar. 22d.	Ap. 23d, '66
Least mean daily press.,	29 051	29·241	28 884
" date,	Ap. 23d.	Mar. 22d.	Ap. 21st, '52
Mean daily range,	0·146	0·162	0·160
Means at 7 A. M.,	29·786	29·821	29·820
" 2 P. M.,	29·730	29·776	29·774
" 9 P. M.,	29 763	29 818	29·806
" for the Spring,	29·760	29·805	29 800
Force of Vapor—Greatest—Inches,	0·694 in.	0·689 in.	0·771 in.
" date,	May 27th.	Ap. 29th.	May 14th, '54
Least—Inches,	·066	·076	·023
" date,	Mar. 17th.	Mar. 6th.	Mar. 5th, '58
Means at 7 A. M.,	·250	·284	·252
" 2 P. M.,	·272	·306	·268
" 9 P. M.,	·277	·303	·272
" for the Spring,	·266	·298	·264
Relative Humidity—Greatest—per ct.,	95·0 per ct.	96 0 per ct.	100 per ct.
" date,	Mar. 21st.	Mar. 9 & 31	often.
Least—per ct.,	18·0	23·0	13·0
" date,	Ap. 29th.	Ap. 24th.	Ap. 13th, '52
Means at 7 A. M.,	68·4	70·4	71·8
" 2 P. M.,	52·1	53·8	52·0
" 9 P. M.,	66·4	67 8	67·8
" for the Spring,	62·3	64·0	63·9
Clouds—Number of clear days,*	26	21	28·1
" cloudy days,	66	71	63·9
Means of sky cov'd at 7 A. M.,	57·5 per ct.	66·7 per ct.	60·6 per ct.
" " " 2 P. M.,	69·7	68·4	63·5
" " " 9 P. M.,	54·5	54·5	49·3
" " for the Spring,	60·5	63·2	57·8
Rain—Amount,	9·590 ins.	15·396 ins.	12·773 ins.
No. of days on which rain fell,	30	37	36·1
Prevailing Winds—Times in 1000,	N80°37′W·251	S62°34′W·172	N75°16′W·186

* Sky one-third or less covered at the hours of observation.

JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

AUGUST, 1866.

CIVIL AND MECHANICAL ENGINEERING.

For the Journal of the Franklin Institute.

Grain Elevators, Cleaners, and Dryers. By ALFRED P. BOLLER, C. E.

Continued from page 11.

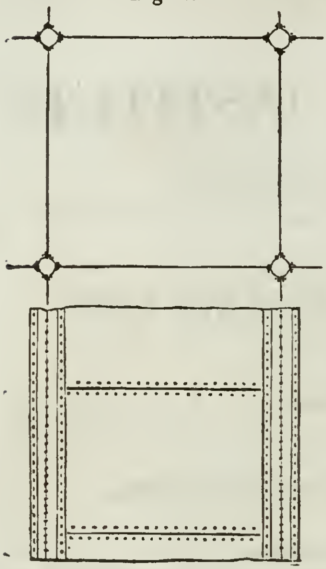
In the last paper a general description was given of permanent elevators and such arrangements in connexion with them as are at present in use for cleaning and drying grain. It now remains to notice briefly the construction and operation of floating elevators. Before doing so, however, it will be interesting to see what progress has been made in constructing bins of wrought iron, for it must be remembered that this department of construction is one that is peculiarly liable to destruction from fire.

We believe that the only permanent elevator constructed of fireproof material, both inside and out, is the one built by the Pennsylvania Railroad Company, at Philadelphia, some three years since. Its capacity is 450,000 bushels of grain, and receives from cars only, transferring to vessels for the European market direct. The shell of the building is brick, the bins themselves being high boiler-plate cylinders, twelve feet in diameter, resting upon parabolic cast iron girders supported upon cast iron columns ten inches in diameter. The roof is slated, the trusses for its support being of wrought iron. The warehouse is situated some distance from the slip, and the grain is carried to the vessel upon an endless canvas belt, protected by a long hollow box through which it passes. A considerable amount of storage room

must be lost from the cylindrical construction of the bins, although it is a very strong one.

The annexed Plate II., Fig. 8, shows an isometrical view of an arrangement for a fire-proof bin proposed by the writer, which, although never as yet practically tried, seems to promise, with simplicity of construction, economy of material and bin space. As in the elevator of the Pennsylvania Railroad Company, the bins are supported upon cast iron columns, but, unlike that elevator, the plan of the bin is rectangular. The bottoms of bins rest upon heavy rolled Phœnix beams, the sides are sheets of boiler-plate iron riveted together, and the intersections are wrought iron Phœnix cylinders rolled in four segments. Each segment has broad lips rolled with it, so that all four may be riveted together, and also to the plates forming the sides, as the sketch plainly illustrates. When the bins are high, the joinings of the plates forming the sides have T-iron riveted upon them the proper distance up in order to obtain lateral stiffness.

Fig. 1.



The annexed figures show a plan and portion of elevation of one of these bins, and how the boiler-plate sheets are introduced between the lips of the segments where they are secured by riveting. The hopper-shaped bottom is readily formed by using either cast or wrought iron cross girders made in the proper form, as represented in the isometrical sketch.

Floating Elevators.—Several attempts have been made to build floating elevators, but perhaps the most successful is the one described as Nimms & Clifford's patent. Two of these have been built, one for the Northern Railroad, to be used at Ogdensburg, and the other (the *Dictator*) for a private party in Buffalo. A detailed description of the latter will illustrate fully their method of working.

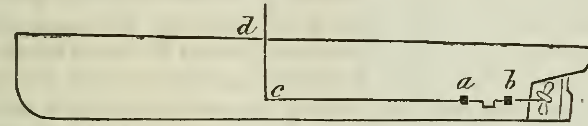
The *Dictator* is a propeller-built vessel, staunchly built, trenailed with locust and galvanized spikes. She is furnished with all modern improvements with that class of vessels, cabins and kitchen complete. The principal dimensions of this vessel are as follows:

Length over all	144 feet.	Width over all	26 feet.
Depth of hold	12 "	Between decks	8 "
Draft of water when loaded	13 "	Thickness of sides	22 ins.
Capacity for grain		16,600 bushels; equal to 500 tons.	
Maximum speed		13 miles per hour.	

She is supplied with a vertical engine having a 20×22 inch cylinder, the steam being supplied from two boilers. The power is transmitted to the elevating apparatus by means of the propeller-shaft,

which is made of forged iron in three sections. One section is connected with the propeller, one section, by means of the crank-arm, to the engine, and the other with the elevating machinery. Any two may be thrown in and out of gear by means of the ordinary clutch coupling. The annexed diagram, Fig. 2, shows the arrangement of the shaft-

Fig. 2.



ing, in which *a* and *b* are the clutch couplings and *c d* a vertical shaft receiving the power for the elevator.

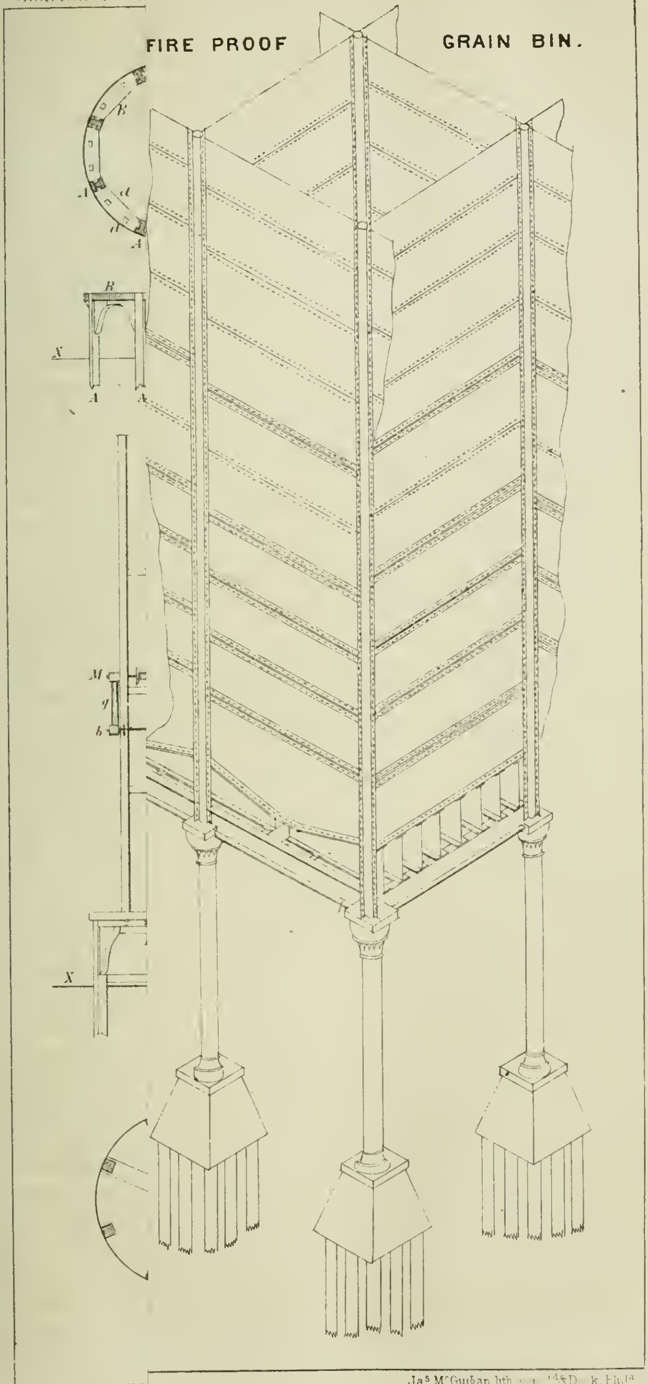
Plate II., Fig. 1, shows the transformation of motion from the horizontal shafting before spoken of to a vertical one operating the elevating machinery; A B is the prolonged shafting from the propeller-wheel; *c*, fly-wheel; *e*, beveled spur-gearing; G, cross-bearer for supporting shaft I; M, solid timbers forming foundation of turn-table bed. Fig. 2 shows plan and elevation of turn-table bed; X Y is the line of the upper deck; A A, &c., heavy oak posts springing from the timber foundations shown in Fig. 1; B, segments dove-tailed into posts A. The posts and segments are further secured by a system of knee-bracing strongly bolted to them, as shown in the drawing; *d d* friction-rollers upon which the turn-table rests. Fig. 3 shows the turn-table, formed of heavy oak segments in two layers, breaking-joint and the heavy frame-work upon which the machinery is supported; an end view and section through centre are also given. From what precedes, the turn-table will be readily recognised in Fig. 4, which shows, in connexion with the turn-table, the arrangement of the machinery which operates it, together with a portion of the upper frame-work and gearing, the receiving hopper, and weigh-scales room. The revolving of the table is effected by means of the hand-brake, A′, attached to the compound lever *a;* B′ B′ are friction-wheels of hard wood. The large wheel has a movable centre, supported on the lever O′, which lever is raised from the floor by a block of oak spiked to one of the foundation posts. To operate the turn-table, the man in attendance to the scales room turns the hand-brake, which presses the larger friction-wheel against the smaller one. The small wheel is attached to the shaft I, (which is the prolongation of I, Fig. 1,) and is constantly revolving. Thus the shaft of the larger friction-wheel receives motion, and, by means of a pinion on its upper extremity, works on the rack along the top edge of the turn-table, which rack is a semi-circumference of the whole table. Upon the same shaft with the smaller friction-wheel, and above it, is a spur-wheel, C′, operating upon its follower, D′, at the centre of the table, shown by their pitch circles merely in plan. Upon the centre shaft is a large spur-wheel, E′, with its follower, F′, which follower carries the shaft that operates the elevating machinery above the turn-table. Above the level of the top of the turn-table the elevation shows a portion of the frame-work

for supporting the shafting and gearing, and also the room appropriated to the weighing and receiving hoppers; $q\,q$ are quadrants of a spur-wheel attached to the shaft M N and operated by the pinions $b_{\prime}\,b_{\prime}$; W, windlass for coiling up the rope that raises the leg; H, spur-wheel which operates the pinions; R, receiving hopper; R′, weighing hopper; S, movable discharge spout.

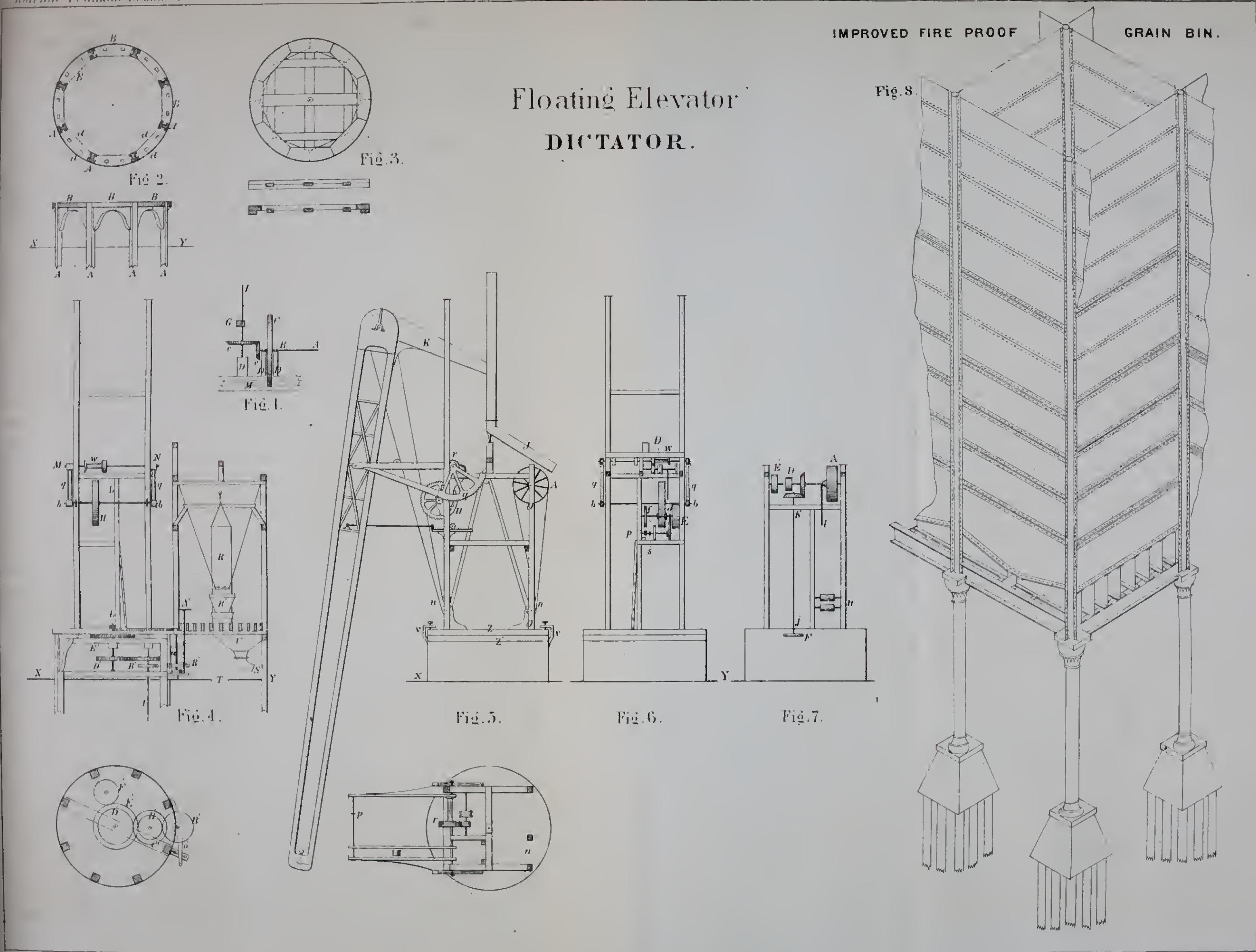
In Fig. 5 the turn-table has revolved, by means of the hand-brake, 90° from its position in the last figure, with the leg thrown over the side of the propeller. This figure also shows the leg with its system of gearing and attachment to the frame-work, and the arrangement for discharging the grain after being elevated. The leg is made from boiler-plate iron riveted together, being connected at the corners by angle irons. It might be remarked, at this place, that the only iron leg ever as yet made is the one belonging to the *Dictator*, and it is one-third lighter than a wooden one, and immensely stronger. Square bars are secured to the sides, and slide in corresponding grooves in powerfully braced jaws swung at their centre on an axis, which is supported by a pair of strongly framed oak arms. The centre of movement of these arms lies immediately back of the posts, and is on, and firmly secured to, the shaft that carries the quadrants. (See Fig. 4.) These quadrants are operated by the spur gearing before described, and give a vertical motion to the arms, by means of which the jaws are raised, carrying the leg with them. Below the arms and quadrants is a grooved casting firmly secured to the posts, in which a rack slides, operated by a smaller pinion. (See *p*, Fig. 6.) At the outside end of the rack, a wrought iron fork is connected by a movable joint; this fork embraces the leg and regulates the amount of throw in a horizontal direction. At the foot of the leg is a set of sheaves, the ropes from which pass around another set at the end of the oak arms, and are wound up on the windlass before mentioned. In order that these ropes may be wound up regularly, they are directed by means of a pulley. (See *p*, in plan.) The mode of operating windlass will be shown further on. The belt carrying the buckets is driven by a head-pulley, the belting for which is shown in the figure passing over two sets of tension-pulleys, $n_{\prime}\,n_{\prime}$. In order to keep the axes of the tension-pulleys perfectly level, the journals are swelled at their ends, having corresponding cavities in the journal-boxes—a kind of ball and socket arrangement. A pair of set screws at each end, one above and one below, regulate the alignment of the axes. The tension-pulleys, sliding in grooves, have for rise and fall the distance O O′. At the foot of the elevator-leg are a pair of set screws, which are used either for tightening or for slackening the bucket-belt. The grain, when elevated, falls into a spout, K, the mouth of which slides in a vertical one, which directs the grain into a discharge-spout, *j*. This discharge-spout in turn directs the grain into the receiving hopper shown in the last figure. Immediately under the receiving hopper is the weighing hopper, from which the grain falls into a small hopper, U, just below the level of the top of the turn-table. The movable spout, S, either directs the grain through a port in the side of the propeller into a vessel adjoining, or into its

Vol. LII. 3rd Series, Pl. II.

FIRE PROOF GRAIN BIN.



Jas McGuigan lith ... & D... k. Phila



Floating Elevator
DICTATOR.
IMPROVED FIRE PROOF GRAIN BIN.
Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8.

own hold by means of the receiving hatch T. Z is the turn-table; Z′, turn-table bed; $v_{\prime}$ $v_{\prime\prime}$, iron dogs for clamping turn-table when in position; *r*, spur-wheel with drum operating windlass.

Fig. 6 shows the side elevation of the machinery to the left of the centre line in the last figure; *q q* are the quadrants; W, windlass; D, driving-pulley for hoisting apparatus, the belt running to D in Fig. 7. This driving-pulley is thrown in and out of gear by means of a clutch and lever. *b b* are the pinions working quadrant. On the pinion-shaft is a spur-wheel (*vide* Figs. 4 and 5) operated by a pinion on a shaft, having attached to it, by a clutch coupling, a pulley, E, which receives the band from E′ in Fig. 7, and is used to raise or lower the leg; S is a small ratchet for working by hand the rack which has the iron fork attached to it previously described; *f* is a friction strap and wheel for lowering quadrants. Fig. 7 presents the side elevation of the machinery to the right of the centre line in Fig. 5. F is the spur-wheel shown by pitch circle F′ in plan of Fig. 4, and receives all the power for the machinery above the top of the turn-table, which power it transmits by means of the vertical shaft J K. By means of beveled spur-gearing, the power is transferred to a horizontal shaft. A is the main driving-pulley for working bucket-belt of the leg, shown at A, Fig. 5; it is thrown in and out of gear by the lever *l;* D and E′ are driving-pulleys before described in connexion with Fig. 6; *n* are tension-pulleys, sliding up and down between guides, shown in plan of Fig. 5. Having traced in detail the various parts and mode of operating the machinery, let us group them together and follow the whole connectedly, and take a glance at the practical working of this elevator. The average amount of grain carried by lake vessels is 16,000 bushels; some few carrying 25,000, and one or two as much as 30,000 bushels. Suppose a vessel desires to unload a cargo of 10,000 bushels. For that purpose the propeller carrying the elevator comes alongside of her, and they are lashed securely together. The elevator-leg is raised, pushed out horizontally, and is lowered into her hold. The grain is then elevated and discharged by means of the spouts previously described, weighed, and either transferred to a canal-boat on the other side, or stored in her own hold. Should there be, in addition to the grain, rolling freight to be unloaded, it may be stored between decks. All rolling freight is raised by means of a shaft running the whole length of the propeller, attached to the under side of the upper deck. This shaft carries friction-rollers and windlasses at every hatchway. By this means flour in barrels, boxes, castings, &c., are handled very rapidly at the same time that the grain is being elevated. The propeller has a full load now, and moves off to her pier. She first discharges her rolling freight, which is done by the same machinery with which she receives it, and is then ready to discharge her grain; or both operations may be conducted at the same time. The grain is spouted into bins placed along the edge of the pier. The construction and arrangement of the bins is restricted to no particular plan, other than their being placed along the edge of the pier or dock. The plan of bins adopted by the inventor of this floating elevator is a simple framing, so as to make the bins 12 feet in all dimen-

sions, and to hold 1300 bushels of grain, which is equal to a weight of about 41 tons. The bottoms of the bins are raised high enough to allow freight cars to run under them, and also to give room to a small movable weighing hopper running above the cars. To store 200,000 bushels of grain would require 154 bins, stretching over a distance of about 1800 feet. There might be two rows of bins instead of one, reducing the lineal distance one-half. Two trains of cars could be loaded in a very short time, especially if time is not lost by weighing before loading. The height to which these bins may be carried is, of course, limited by the position of the discharge-spout of the elevator. All that it is necessary to bear in mind is, that the bins must be no higher than the angle of discharge for grain, the minimum for which being 22°.

A considerable amount of room could therefore be gained by using up the space required by the weighing hopper for bin space, and perform all the necessary weighing on platform scales after the cars are loaded. Before closing this brief sketch of permanent and floating elevators, it may be interesting to know their usual cost. A few figures in regard to cost were mentioned in the first paper, but they represented the price of material and labor before the present inflation of our currency. A modern built permanent elevator to store 250,000 bushels of grain, with a transfer capacity of 5000 bushels per hour, would, at the present time, cost about $125,000, and this is exclusive of engines and boilers, and, of course, of drying or cleaning arrangements. The engines and boilers would be worth about $20,000 additional; making a total cost of a permanent elevator at least $145,000 before a bushel of grain could be stored.

The *Dictator* floating elevator cost $80,000, made up as follows: Elevating machine, $15,000; propeller engine, wheel, and shafting, $10,000; two boilers, $10,000; hull, complete, $45,000. In considering the cost of a floating elevator, there ought properly be added the cost of bins, and these two items would approach pretty nearly to the cost of a permanent elevator.

An Enormous Bridge.

From the London Athenæum, November.

A contemporary gives the following striking details of an enormous bridge now being constructed for the London and North-western Railway Company across the Mersey, between Runcorn and Liverpool. It approaches the north-east bank of the river at Runcorn Ferry, which it crosses at Runcorn by an enormous bridge, consisting of three wrought iron trellis girder openings, 305 feet in width each, and 75 feet in height, on the under side of the girders, above the level of the river at high water, thus permitting any vessel of ordinary size to pass under it. On the Lancashire, as well as on the Cheshire side of the river, these girders are supported by huge abutments crowned with castellated turrets, rising nearly 40 feet above the railway level, whilst in the river the girders are supported by immense stone piers. Having passed the Mersey, the railway is carried through the town of Runcorn

by a viaduct of 32 arches, passing over the Duke of Bridgewater's canal, a short distance from the west side of Runcorn church. By this addition to the railway eight miles are saved in the distance between Liverpool and London.

On Incrustation of Marine Boilers. By Mr. P. Jensen.

From the London Mechanics' Magazine, May, 1866.

At a meeting of the Society of Engineers, held on May 7, Zerah Colburn, Esq., President, in the chair, the following paper was read: The question of keeping marine boilers free from deposit or incrustations has, for many years, been one of the most prominent before the profession—in fact, ever since the first steamer entered sea-water—and it is still well worthy of our closest attention. It presents itself to us principally in three distinct forms, viz: safety against explosions, economy of fuel, and durability of the boiler itself. Now, we all know that sea-water causes incrustation and corrosion when boiled in a close vessel like a steam boiler. It is not, however, intended to enter into the question of internal corrosion of marine boilers, though closely connected with the subject before us, for fear of extending the length of this paper; but we may, in passing, note the fact that internal corrosion, below the level of the water in a marine boiler, does take place to some extent, where the scale has been removed, but that otherwise this scale, so injurious when allowed to accumulate to any thickness, acts the part of a shield or protector to the plates of the boiler, against the action of certain salts contained in sea-water, of which the muriate of magnesia is by far the most destructive, though happily small in quantity. And here the author may be allowed to call the attention of the meeting to an excellent paper, "On the Wear and Tear of Boilers," read before the Society of Arts, April 26, 1865, by Mr. F. A. Paget,* who treats the subject of corrosion of boilers very fully. In the ordinary practice of sea-going steamers with common condensers, the feed-water is drawn from the hot-well of the condenser, and thence forced into the boiler at some point or points near the bottom, and at a temperature of about 110° Fahr. The evaporation of steam leaves all, or sensibly all, saline or other extraneous matters contained in the water behind in the boiler, and, unless some means were adopted against it, we should, of course, soon get the boiler choked with incrustation or deposit. The means proposed or adopted for this purpose are many and varied, as will be seen in the sequel; but this much is certain, that any considerable thickness of scale allowed to accumulate renders the plates impervious to heat to a great extent, as this scale is a bad conductor. The heat generated in the furnace, and heating the plate next to it, cannot readily enough penetrate as far as the water, which, if in constant circulation, continually exposes fresh particles to the action of heat. The consequence is the overheating of the plates, and this to such an extent that holes may be burnt nearly through, leaving a sheet of iron

* See *Jour. Frank. Institute*, vol. l., 1865, page 13.

the thickness of writing paper. That explosions do and must occur by thus weakening the plates, or by rents thus formed, is an established fact, and has, for many years, formed the subject of many investigations and different theories, among which that called the percussive, first started and since completed by Mr. Zerah Colburn, seems the most natural, and has now probably become more generally adopted than any other. But even only partial explosions, caused by rents or collapse of internal parts of the boiler, have proved dangerous by scalding those that happened to be near at the time. The conducting power of wrought iron decreases with the temperature, so that at 400° Fahr. it has little more than half that at 32° Fahr.; how it stands with still higher temperatures we do not know as yet. If from some reason or other, such as the coating of the plate with incrustation, which has sixteen times less conducting power than iron, the plate, with its covering of crust, should become heated to above 340° Fahr., then the water would exist on its surface in a speroidal state, and thus only slowly and by the forcible ejection of it by colder water enable the heat contained in the plate to diffuse itself into the water; thus the plate would get hotter and hotter, and at last burn or oxidize where next to the fire. It is thus that plates are burned nearly through on account of incrustation. Important as is the question of the safety of the marine boiler against explosions, it cannot be denied that the economy of fuel, as regards marine boilers, has at all times, being a mere question of pounds, shillings, and pence, commanded, it is believed, as much attention as the consideration of human lives: witness the numerous patents, amounting to about one hundred and fifty, that have been taken out in this country for the prevention of incrustations and consequent loss in evaporative duty in marine boilers. Now, this is not an occasion for speaking about the patent laws, or entering into the desirability of maintaining, altering, or abolishing the same; but as one argument in favor of maintaining them struck the author while preparing this paper, which has a direct bearing on this and most other engineering questions, it would be worth while to hear what the opponents of the patent laws have to say against it. The question is simply this: How and where should we find such a complete record of the progress of engineering, inventive, and progressive talent but for the record of the Patent Office? In spite of all the nonsense that is patented, no doubt in sober earnest, still we find a vast amount of information in the specifications of patents. Would those that speak against patent laws like to do without the patent specifications? To return to the subject. It has been said above, that the scale has sixteen times less conducting power than iron. In an inquiry on incrustation of marine boilers by a Frenchman, M. Cousté, (*Annales des Mines*, 1854,) a paper hardly noticed in this country till Mr. Robert Trefusis Mallet, in the *Practical Mechanics' Journal*, September, 1862,* gave an extract of it, the following is stated: That, with marine boilers, starting quite clean inside, a loss of 8 per cent. or 10 per cent. of the evaporative duty of the fuel takes place after the first few days' work,

* See *Jour. Frank. Institute*, vol. xlv., 1863, page 51.

(a fact every marine engineer is aware of.) At Bordeaux, he found 15 per cent., and at Havre, after some days' constant work, he observed 40 per cent. In general practice, he says, it has been estimated that 40 per cent. of the heat of the fuel is lost by internal incrustation or deposit.* He gives the following analysis of the incrustations of French ocean steamers:

Stations.	Sulphate of Lime.	Carbonate of Magnesia.	Free Magnesia.	Iron and Aluminum.	Water.
Hamburg, (deposit from the surface of boiler partly crystalized)	85·20	2·25	5·95	....	6·5
Mediterranean tubular boiler, (amorphous)	84·94	2·34	7·66	·41	4·65
Mediterranean, (amorphous deposit)	80·90	3·19	10·35	6·50	4·56

The water contained is believed to be mechanically present in the pores of the scale, and not chemically dissolved. Of course, marine boilers are scaled as often as it can be done; but, for long voyages, it is often out of the question. Starting with 20 lbs. pressure in the boiler, and clean fires, it is generally found that, on the second or third day, in spite of greater exertions of the stokers and harder firing, only 19 lbs. or less, can be kept constantly, and this loss in efficiency goes on at an increasing rate. In eight days' constant steaming it has been found (in one instance) that, starting with 22 lbs. pressure, the same was reduced to 15 lbs. at the end of the voyage; this, it is supposed, without at all forcing the firing. Take another instance at random, the *Persia* log, from the year 1858, September 30 to October 9, inclusive: Total number of nautical miles traveled, 2886; total quantity of coals consumed, 1402 tons. But whereas the consumption of coals per hour per indicated horse power was 3·95 on 30th September, (she left New York on the 29th.) it had increased to 4·314 on the 8th of October, (*Artizan*, May, 1860.) These few items illustrate sufficiently the well-known fact that incrustation, even only as thick as paper, has a very great and perceptible influence tending to counteract the economy of fuel.

As to durability, marine boilers, with all care, on an average, only last five years; but this is chiefly owing to internal and external corrosion, rendered more intense by the salts contained in sea-water, which, besides, promotes galvanic action in various ways. This must be understood to apply to boilers properly managed; that is to say, in such a way that only a very thin scale is allowed to be formed; for, as mentioned above, if thick scale is formed anywhere in places exposed to the heat of the furnace, or the escaping gases, this circumstance contributes directly to the burning away or oxidizing of the

* This is, however, overrating the case considerably.

plates. This fact, that marine boilers wear out so quickly, must, as far as can be seen at present, remain unaltered so long as salt water is employed, and, in spite of repeated trials, and more or less success of surface condensing, in some instances, still we are far from the general introduction of surface condensing, and, considering the vast number of marine engines in existence worked with common injection condensers and salt water in the boilers, leaves the importance of the subject under consideration intact. It is now proposed to give a general explanation of the action of sea-water as it obtains in the marine boiler. The specific gravity of sea-water varies according to different localities; and calling that of pure distilled water 1000, the average specific gravity of sea-water, according to Farraday, is 1027. For sea-water of the specific gravity of 1027·2, such as he used in his experiments, one cubic foot weighs 64·1416 lbs., or 1026·265 ozs. avoirdupois, and contains of

	Ounces.
Chloride of sodium, or common salt	25·762
Muriate of magnesia..	3·282
Sulphate of magnesia..	2·212
Sulphate of lime..	1·013
Total..	31·269

besides small quantities of other salts, but too minute to be of any consequence.

Dr. Ure found the largest proportion of salt held in solution in the open sea to be 38 parts of 1000, and the smallest 32. The Red Sea, however, contains 43 parts in 1000; the Baltic contains 6·6; the Black Sea 21; the Arctic Ocean 28·5; the British Channel 35·5, and the Mediterranean 38.

The following table shows the boiling point and specific gravity of water of different densities at a barometric height of 30 ins. of mercury:

	Saltness.	Boiling point.	Specific gravity.
Pure water	0	212°	1·000
Common salt water	1-32d	213·2	1·029
	2-32d	214 4	1·058
	3-32d	215·5	1·087
	4-32d	216·7	1·116
	5-32d	217·0	1·145
	6.32d	219·1	1·174
	7-32d	220·3	1·203
	8-32d	221·5	1·232
	9-32d	222·7	1·261
	10-32d	223·8	1·290
	11-32d	225·0	1·319
	12-32d	226·1	1·348

The deposit of salt begins at a density of 4-32d, and at 12-32d we have arrived at the point of saturation, or the point at which water is incapable of dissolving any more. According to M. Cousté, an im-

perial gallon of water is capable of holding in solution at 60° Fahr. and at boiling point, viz: in the open air, the following weights, nearly:

	60° Fahr.	Boiling point.
Carbonate of lime	Merely traces.	Merely traces.
Silica	70 grains.	" "
Sulphate of lime	170 "	" "
Carbonate of magnesia	3·25 ounces.	" "
Sulphate of potassium	10 "	40 ounces.
Chloride of sodium	32 "	30 "
Chloride of magnesium	266 "	580 "
Nitrate of lime	500 "	580 "
Chloride of lime	540 "	unlimited.

The order of deposition in the boiler as the water becomes concentrated is: 1st, carbonate of lime; 2d, sulphate of lime; 3, the salts of iron and oxides, and some of those of magnesia; 4th, the silica or alumina usually with more or less organic matter; and 5th, chloride of sodium or common salt. Now, it is well known that sulphate of lime is the worst of all the salts in a marine boiler. We have seen that 12-32d, or 37 in 100, is the point of saturation for common salt, but in the case of sea-water, which contains other salts besides, 36 parts in 100 saturate at 226°, and 30 in 100 at 228°. Now, taking 20 lbs. pressure, which is the most prevailing now, this, with a saturation of 3-32d to a rise of 1·2° per 1-32d, according to Professor Rankine, corresponds to a temperature of (say) 262·9° Fahr. How much salt can be held in solution at that temperature is not known to the author; but it is well known that the quantity decreases with increased temperature, and this is the reason of our not having yet arrived much beyond 20 lbs. pressure in marine boilers working with salt water. In marine boilers we have chiefly to do with sulphate of lime, the proportion of the same so largely preponderating in the incrustation on analysis. As to carbonate of lime, this enemy to boilers is, fortunately, not a constituent of salt water, except in the Mediterranean, which contains a trace of it, (·001 in 100 parts.) Sulphate of lime forms deposits at all temperatures and at all densities. Salt, on the contrary, forms deposits, as we have seen in the foregoing, not to any extent except when in the quantity of 3-32d or 4-32d, the quantity of the same required for saturation decreasing with increased temperature, and the amount of deposit that will take place long before the point of saturation having been arrived at increasing with increased temperature or pressure. Sulphate of lime will deposit at any temperature; but it so happens that increase of temperature also increases the amount of deposit of this salt; for, according to M. Cousté, the solubility of sulphate of lime at different temperatures is as follows. The table indicates the solubility for different temperatures as well as degrees of concentration at which the saturation of sulphate of lime takes place:

Degrees of ærometer corresponding to the saturation.	Temperature.		Total pressure in atmospheres.	Solubility, or proportion of sulphate of lime in 100 parts of water at saturation.
	Fahr.	Cels.		
$12\frac{1}{2}$	217·4	103·00	1	·500
12	218·84	103·80	1	·477
11	221·27	105·15	1	·432
10	227·48	108·60	$1\frac{1}{4}$	.395
9	231·8	111·00	$1\frac{1}{4}$	·355
8	235·76	113·20	$1\frac{1}{4}$	·310
7	240·44	115·80	$1\frac{1}{2}$	·277
6	245·3	118·50	$1\frac{1}{2}$	·226
5	250·	121·20	$1\frac{1}{2}$	·183
4	255·2	124·00	2	·140
3	261·68	127·60	2	·097
2	266·	130·00	$2\frac{1}{2}$	·060
1	271·94	133·30	$2\frac{1}{2}$	.023

Now, this table, and that of the amount of salt which can be held in solution at high pressures (say 20 lbs.), a table, the author believes, not to be found anywhere, would give us as near as possible the quantity of water that ought to be blown out of a boiler to prevent, first, accumulation of chloride of sodium, and second, the deposition of sulphate of lime in any quantity injurious to the boiler in any high degree. True, there is one way of getting over the difficulty, viz: working with a lower pressure; but this is out of the question for several reasons, and we must hence use experience and experiments as our guide. From the foregoing, it will be clear that every pressure requires a different treatment and a different amount of water to be blown off. If you blow off more than is necessary to prevent accumulation of salt in the boiler, you have to pump a greater quantity of feed-water in, and consequently a greater amount of sulphate of lime in solution, which will be deposited as a hard tenacious scale. On the other hand, if you blow off too little, you will certainly get less sulphate of lime, but the accumulation of common salt will ultimately choke the passages in the boiler. This maxim, though true in theory, is modified in practice, because of disturbing elements, viz: the more or less rapid circulation of the water. To strike the just balance it is, as before said, necessary to be guided by experience. It seems that ignorance has prevailed in high quarters till very late years because of want of data. Thus we find that Mr. James Napier read a paper, in 1859, before the Institution of Engineers of Scotland, in which he recommended the use of a much larger generator, (a sort of tubular feed-water heater, the heat of the brine blown off being made use of for that purpose,) and blowing off to a greater extent than generally used. He tried the experiment himself, and gave the results in a paper, read February 17, 1854, before the same Institution. For the screw steamer *Lancefield*, trading regularly between Glasgow and the Hebrides, he made a regenerator of ten times the usual surface, and blew off to such an extent as to keep the density of the water in the boiler at very nearly the same point as the water in the sea. After

four weeks' running, the boiler was examined, and instead of its being clean and free from scale, he found, to his surprise, it was coated with a much thicker scale than under usual circumstances, but soft, like newly made mortar, but it dried and hardened before he could get it all out, and it was then nearly as difficult to scrape as the ordinary hard scale. On one voyage, when he was present himself, he gave the boiler as much feed as the pump would do, and he observed then that the water in the gauge-glass was muddy. He continued the experiment for six months, but with lesser quantities of feed, and blew off till the tubes of the regenerator gave way, and then he discontinued. He saw then M. Cousté's paper, and the table contained in the same, which shows that at two atmospheres pressure sea-water becomes saturated with sulphate of lime, even at the ordinary density, and as he loaded to 40 ℔s., and generally worked at about 30 ℔s., he saw at once the explanation of the phenomena. Although he blew off constantly from the surface by a conical tube, only some of the deposit of precipitate matter could be got rid of. This tallies exactly with the experience of some others. Some steamers in the American navy work with about or nearly 30 ℔s. pressure and salt-water, but it is believed not with our ordinary tubular boiler, but with long cylindrical boilers, having large round tubes and very ample water-way. In the discussion following, Mr. Elder said he had worked marine boilers with 30 ℔s. to 35 ℔s. and salt-water. One naturally expected to find most deposit in that section of the boiler which contained most salt and lime, he said, but in a boiler divided into eighteen parts (supposed to refer to his spiral flue high-pressure boiler) he found that though in the last section there was $2\frac{1}{2}$ times more salt in the water than in that of the first section, yet the deposit of lime was about equal in all parts. He concluded that the amount of deposit of lime depended on temperature, and not quantity of lime in it. The Americans, he said, ran with 40 ℔s. pressure, and did not appear to suffer from deposit, but they cleaned the boiler whenever they came into port. He found the deposit to be greatest where there was no current. He had observed boilers running with 45 ℔s. for three or four months, and there was not much more deposit than when working with 25 ℔s. He believed that there was a greater tendency for the lime to separate and deposit, but it did not necessarily settle down on the heating surface of the boiler.

The *Mechanics' Magazine*, in an article on "Incrustation in Marine Boilers," February 24, 1860,* mentions Mr. James R. Napier's paper, and assumes, for want of better data, 28 parts of sulphate of lime to 1000 of solution as the limit of saturation in boilers working at a pressure not exceeding 20 ℔s., and finds that, with this assumption, half the water must be discharged to keep the boiler clean, and this is affirmed by the practice of the British and North American Mail Company and others. Mr. Thomas Rowan found that when he had evaporated $\frac{2}{10}$ and $\frac{4}{10}$ of the water, a trace of sulphate of lime deposited; $\frac{5}{10}$ of the water, sulphate of lime deposited in larger quantities; $\frac{6}{10}$ of the water, sulphate of lime decided in larger quantities;

* See *Jour. Frank. Institute*, vol. xl., 1860, page 297.

$\frac{8}{10}$ of the water, sulphate of lime in very large quantities, also magnesia, and salt began to form. It is probable, therefore, that half or more of the water would have to be blown off in order to prevent formation of crust. This means that the density of the water should be kept at $\frac{2}{32}$, for as sea-water contains $\frac{1}{32}$ in its pure state, it is evident that half the water must be blown off to keep it at double its natural density. It may here be remarked that a density of $\frac{2}{32}$ is very generally kept in marine boilers, using about 20 lbs. pressure of steam, and if this be constantly and carefully attended to, no considerable or deleterious thickness of scale accumulates, at least in places where the circulation is good.

(To be continued.)

Cost per Ton per Mile of Traction Engines.

From the London Mechanics' Magazine, March, 1866.

Experiments have recently been made with one of Messrs. Aveling & Porter's traction engines, to determine the cost per ton per mile of conveying goods by this means. The result of a carefully conducted trial trip of 26 miles showed that the total cost per ton per mile was 2·93*d.* This amount comprises 1·592*d.* per ton per mile for working expenses, and 1·338*d.* for turnpikes, which must be taken as exceptional. The engine used was one of the pair recently employed to take the base of the Wellington Memorial from Reading to Strathfieldsaye, and the trial proved highly satisfactory, as the above figures indicate.

Fabrication of a Cement with a Basis of Plaster of Paris, or Gypsum.

From the London Builder, No. 1210.

The plaster is first burned or roasted, in the ordinary way, in an appropriate furnace, so as to drive off the water. After this, it is broken into small fragments, which are immersed in a solution of alkaline silicate, containing an alkaline carbonate. The solution which answers best is composed of silicate of potash, containing a sufficient number of equivalents of carbonate of potash, to avoid the precipitation of the silica, in the following proportions: 0·880 kilog. (1·94 lb.) of silicate of potash containing 0·255 kilog. (·56 lb.) of carbonate of potash, in 4·54 litres (a gallon) of water, a solution having a specific gravity of 1200, but which may vary according to the use for which the cement is intended. As, for example, it can be employed of the strength above indicated in a great many cases where the best quality is required; and, if an ordinary cement is only necessary, it can be diluted with two parts of water to one of the solution. If a cement be required to harden slowly, sulphate of potash may be added to the carbonate, so that the endurating action of the silica upon the plaster may thus be varied in tone at pleasure. After having left the plaster steeped in the solution for twenty-four hours or so, it is taken out and left to drain in a compact mass, in order that the diffusion of the solution through the plaster may take place more effectually; the cement

is then taken back to the furnace, and reheated to 150° or 250° C., (302° to 482° Fahr.,) to drive off all the water, after which it is ground to powder, and can be colored to any desired hue by mixing with a pigment.

On the Results of a Series of Observations on the Flow of Water off the Ground, in the Woodburn District, near Carrickfergus, Ireland; with accurately recorded rain-gauge registries in the same locality, for a period of twelve months, ending 30th June, 1865. By ROBERT MANNING, M. Inst. C.E.

Read before the Institution of Civil Engineers, April 24, 1866.

From the London Civil Engineer and Architect's Journal, June, 1866.

It was stated that the surface of the ground was chiefly composed of bare mountain pasture and grazing land, the surface rock being almost entirely tabular trap, overlying the chalk, with here and there patches of green sand. Three rain-gauges were placed at the respective elevations of 300 feet, 750 feet, and 900 feet above the level of the sea; and two stream gauges were erected, one on the southern branch of the river, which received the drainage of 2076 acres, and the other on the northern branch 1329 acres. The stream gauges were rectangular notches with sharp edges, such as were used by Mr. Francis, at Lowell, and the formula for calculating the discharge was that deduced from those well known experiments. The observations were nearly eight hundred in number, and were recorded in an appendix. From a summary of the results, it appeared that the rain-fall for the year was 35·867 inches, or nearly 18 per cent. above that of Belfast. For the six months, from November to May, the rain was 14·766 inches, producing a flow of 14·351 inches, while from May to November these quantities were 21·101 inches and 7·357 inches. The minimum flow off 1000 acres occurred in August, and amounted to 11 cubic feet per minute; the maximum, in September, to 3180 cubic feet per minute; and the mean monthly flow was at its minimum in July, and was 29 cubic feet per minute.

The particulars of one year's rain having been thus ascertained, it was assumed that the rain-fall on the Carrickfergus Mountains bore a constant ratio to that at Queen's College, Belfast, where a daily register had been kept for fourteen years, and that it was the greater by 16 per cent. The results then arrived at were, that the maximum rain-fall in 1852 was 47·71 inches, the mean for the fourteen years, 1851–64, was 38·42 inches, the average of the three dry years, 1855–56–57, was 32·76 inches, and the minimum in 1855 was 28·8 inches.

The question then remained, how much of this rain-fall was available for water supply? Twenty or thirty years ago, the evaporation was taken as proportional to the rain-fall, and was variously estimated at one-sixth, one-third, and two-thirds of the mean annual rain, according to circumstances. Now, the balance of opinion seemed to be that the amount of evaporation was not proportional to the rain-fall; that

it was either constant or within narrow limits, where there was an identity or similarity in the physical features of the districts compared; that it varied under different circumstances in this kingdom from 9 inches to 19 inches; and that its amount in any particular case must be left to the experience and judgment of the engineer.

The author calculated that the loss, or the difference between the rain-fall and the supply, which was the resultant fact of greatest importance to the engineer, varied in the Woodburn District from 11·79 inches to 15·16 inches, the mean annual loss being 13·71 inches. The supply ranged from 14·57 inches to 35·37 inches, the mean annual supply being 24·71 inches. The years of maximum and minimum supply were also the years of maximum and minimum winter rain. In the years of 1856 and 1857, in which the rain-fall only differed by 0·41 inch, the difference in the loss was 3·22 inches, arising from the fact of there being a winter rain-fall of 15·96 inches in the former, and of 22·03 inches in the latter year.

The particulars were then given of the storage required for all quantities, from the mean annual supply down to that of the minimum year, from which it appeared that to store the whole rain yielded by the Woodburn District, 24·71 inches, a reservoir capable of containing 431 days supply would be necessary; for the average of the three dry years, 18·28 inches, 132 days would be required; while for the minimum, 14·57 inches, 119 days would be sufficient. Diagrams were added, showing the storage worked out for each month of the fourteen years, and for quantities of 24·72 inches, 20 inches, and 18 inches, and showing the state of the reservoir for a supply of 24 inches for eleven years, and 20 inches for the three dry years. It was remarked that, although the water in store attained its minimum in different years, that minimum invariably occurred in the month of October, and that, as regarded the economical supply of water from the district under consideration, it would not be prudent to attempt to store a greater quantity of rain than about 10 per cent. over the average supply of the three dry years, provided the extent of the gathering grounds could be increased.

The question of water power was then incidentally alluded to, and it was remarked that, in dealing with useless and injurious floods, and in providing a town supply, care should be taken not to induce the destruction, by instalments, of the whole water power of the country, and injuriously to interfere with the natural regime of rivers. The proportion of the mean annual flow of both branches of the Woodburn River, from a rain basin of 4750 acres, applicable to the supply of Woodlawn Mills, was then determined, and the calculations and results were given in detail. The tables showed, that of the total flow off the ground, 21·71 inches, there was lost on Sundays and by floods 12·22 inches, leaving 9·49 inches, or nearly 44 per cent., available for the supply of the wheel, which was equivalent to 194 days full work during the year, or 1·78 times the mean flow of the stream. If the capacity of the wheel were reduced to 1·5 of the flow, it would work for 213 days, if to 1·25 of the flow for 218 days, and if just equal to the flow it would work 243 days.

Steel for Columns.

From the London Builder, No. 1211.

In France a few experiments were made some time ago by M. G. H. Love upon small pillars made of Turton's steel, and having rounded ends. These pillars were 1 centimetre, or 0·39 inch, in diameter, the lengths being ten, twenty, and thirty times the diameter. The steel of which the pillars were composed was found by experiment to have a tensile breaking strength of 108,500 lbs. per square inch. According to *Engineering*, the results show that, as in the case of cast and wrought iron, the resisting power of steel to compression decreases as the proportion which the length of the column bears to the diameter is increased; but this decrease in strength does not seem to be so rapid as in the case of the two first-mentioned materials. M. Love's own deductions are, that steel and cast iron columns, having a length of from one and a half to five diameters, offer about the same resistance to compression; whilst columns of wrought iron of the same proportions offer only about half such resistance. When the length of the column is increased to ten diameters, however, he considers that steel offers a greater resistance than cast iron, in the proportion of 41 to 31, the proportionate resistance of wrought iron being represented by 17. As the proportion of length to diameter increases, the resisting power of cast iron diminishes more rapidly than that of wrought iron, and that of wrought iron more quickly than that of steel, so that when the length reaches forty diameters, he estimates the strength of similar columns of the three materials to be in the proportion of the numbers 375, 562, and 1500. It is wrong to found a law upon so few experiments; but, if the data above given are confirmed by future trials, steel will prove a valuable material for resisting compressive strains.

Water-proofing Walls. By Frederick Rogers, Captain R. N.

From the London Builder, No. 1212.

Observing in the *Builder* a notice respecting damp walls in outbuildings, allow me to suggest a probable cure.

While in Dorset, I was applied to by a lady for a remedy for the above, and as I had for many years been in the habit of applying "bright American varnish" with great success to very exposed woodwork, I recommended the lady to make an experiment on the part of her house where not much seen. On passing by a few weeks afterwards, I observed all the front glowing to an evening sky.

On inquiry, I found that the varnish had so well succeeded in a small way that the lady had applied the same to the whole building, with equal success; and, when afterwards painted, there was no appearance of wet or "varnish."

The "bright American varnish" is very inexpensive, costing, I think, about 3*s*. per gallon, and may be procured from most sea-ports. I should recommend one coat of varnish as a trial, and if not quite successful then another, followed by three good coats of paint.

On Uniform Rotation. By C. W. Siemens, F. R. S.

From the London Artizan, June, 1866.

The paper sets out with an inquiry into the conditions of the conical pendulum as a means of obtaining uniform rotation. This instrument, as applied by Watt to regulate the velocity of his steam engines, is shown to be defective, first, because the regulated position of the valve depends upon the angular position of the pendulums, and, therefore, upon the velocity of rotation, which must be permanently changed in order to effect an adjustment of the valve; and, secondly, because when the balance between force and resistance of the engine at a given velocity is disturbed, the angular position of the pendulums will not change until a power has been created in them, through acceleration of the engine sufficient to overcome the mechanical resistance of the valve, giving rise to a series of fluctuations before a balance between the power and resistance of the engine is re-established.

These defects in Watt's centrifugal governor are shown to be obviated in the chronometric governor, an instrument which was proposed by the author of the paper twenty-three years ago, and which consists of a conical pendulum proceeding at a uniform angle of rotation, and, therefore, at a uniform speed, which is made to act upon the regulating valve by means of a differential motion between itself and the engine to be regulated, which latter has to accommodate itself to the rotations imposed by the independent pendulum. The differential motion wheels are taken advantage of for imparting independent driving or sustaining power to the pendulum; and a constancy of the angle of rotation, notwithstanding unavoidable fluctuations in the sustaining power, is secured (within certain limits) by calling into play a brake, or fluid resistance, at the moment when the angle of rotation reaches a maximum, which maximum position is perpetuated by increasing the sustaining power beyond what is strictly necessary to overcome the ordinary resistance of the pendulum.

The chronometric governor is used by the Astronomer Royal to regulate the motion of the large equatorial telescope and recording apparatus at Greenwich, in which application a very high degree of regularity is attained; but the instrument proved to be too delicate in its adjustments for ordinary steam engine use.

After a short allusion to M. Foucoult's governor, the paper enters upon the description of a new apparatus which the writer has imagined for obtaining uniform rotation, notwithstanding great variations in the driving power, and which consists in the main of a parabolic cup, open at top and bottom and mounted upon a vertical axis, which cup dips, with its smaller opening, into a liquid contained within a casing completely enclosing the cup. It is shown that a certain angular velocity of the cup will raise the liquid (entering from below) in a parabolic curve to its upper edge or brim, and that a very slight increase of the velocity will cause actual overflow, in the form of a sheet of liquid, which, being raised and projected against the sides of the outer chamber, descends to the bath below, whence fresh liquid continually enters the cup. Without the overflow scarcely any power is required

to maintain the cup, with the liquid it contains, in motion; but the moment an overflow ensues, a considerable amount of power is absorbed in raising and projecting a continuous stream of the liquid whereby further acceleration is prevented, and nearly uniform velocity is the result. When absolute uniformity is required, the cup is not fixed upon the rotating axis, but is suspended from it by a spiral spring, which not only supports its weight, but also transmits the driving power by its torsional moment. The cup is guided in the centre upon a helical surface, which arrangement has for its result that an increase of resistance or of driving power produces an increased torsional action of the spring, and with it an automatic descent of the cup, sufficient to make up for the thickness of overflow required to effect the re-adjustment between power and resistance, without permanent increase of angular velocity.

It is shown that the density of the liquid exercises no influence upon the velocity of the cup, which velocity is expressed by the following formula:

$$n = \frac{\sqrt{2gh\left(1 + \frac{\rho^2}{r^2 - \cdot 293\,\rho^2}\right)}}{2r\pi}$$

in which

n signifies the number of revolutions per second,
h the height of liquid from the surface to the brim of cup,
r the radius of the brim, and
ρ the radius of lower orifice of cup,

only the rigidity of the spring must be greater when a comparatively dense liquid is employed.

In order to test the principle of action here involved, Mr. Siemens has constructed a clock consisting of a galvanic battery, an electro-magnet, and his gyrometric cup, besides the necessary reducing wheels and hands upon a dial face, which proceeds at a uniform rate, although the driving power may be varied between wide limits, by the introduction of artificial resistances into the electrical circuit. The instrument appears, therefore, well calculated for regulating the speed of all kinds of philosophical apparatus, and also for obtaining synchronous rotations at different places for telegraphic purposes. One of its most interesting applications is embodied in the "gyrometric governor" for steam engines. This consists of a cup of 200 millimetres diameter and the same height, which is fixed upon its vertical axis of rotation, and is enclosed in an outer chamber, containing water in such quantity that the lower extremity of the cup dips below its surface. The upper edge of the rotating cup is, in this application, surrounded by a stationary ring armed with vertical vanes, by which the overflowing liquid is arrested and directed downward, causing it to fall through a space or zone which is traversed by a number of radial and vertical blades projecting from the external surface of the rotating cup, which, in striking the falling liquid, project it with considerable

force against the sides of the outer vessel, at the expense of a corresponding retarding effect on the cup, increasing its regulating power.

The cup-spindle carries at its lower extremity a pinion, which gears into two planet-wheels at opposite points, which on their part gear into an inverted wheel surrounding the whole, which latter is fastened upon a vertical shaft in continuation of the cup-spindle, and is driven round by the engine in the opposite direction to the motion of the cup. The two intermediate or planet-wheels are attached to a rocking frame supported, but not fixed, upon the central axis, which wheels, in rotating upon their studs, are also free to follow the impulse of either the pinion or the inverted wheel to the extent of the differential motion arising between them. The rocking frame is connected to the regulating valve of the engine, and also to the weight suspended from a horizontal arm upon the valve-spindle, tending to open the valve and, at the same time, to accelerate the cup to the extent of the pressure produced between the teeth of the planet-wheels and the pinion, while the engine is constantly employed to raise the weight and cut off the supply of steam. The result is that the engine has to conform absolutely to the regular motion imposed by the cup, which will be precisely the same when the engine is charged with its maximum or its minimum of resisting load.

The paper shows that the action upon the valve must take place at the moment when the balance between the power and load of the engine is disturbed, and that the readjustment will be effected, notwithstanding a resistance of the valve exceeding 100 kilogrammes—a result tending towards the attainment of several important objects.

Messrs. Phillips' Patent Girders.

From the London Builder, No. 1204.

For some time past several interesting experiments on rolled iron beams of peculiar construction, have been progressing at Mr. Kirkaldy's works, Southwark, of which our readers may desire to have some particulars. Mr. Kirkaldy's machine (a patent,) we may say at starting, is a beautiful work, from the foundry of Greenwood & Batley, of Leeds.

Several years have elapsed since the continental architects and builders began the adoption of rolled iron beams in place of the ordinary wooden girders and joists, and found advantages in the substitution, not only in respect of cost, but also in the facility they obtained for working out conceptions which never could have had an actúal existence under the old mode of construction.

Now, why have we not more generally adopted the use of so convenient a material as rolled iron? Years ago we suggested to the government the offering of a large premium for improvements in the mode of rolling iron. The fact is, that, with our practical habit of regarding things, the builder is popularly believed to be the best judge

of what is necessary. He is supposed to be, at least, practical; and the opinions of such a one will tell with people, in spite of the representations of architects,—men specially educated to discriminate between the fitness and unfitness of things for the purpose intended. And so we find that, although every architect knows cast iron girders are really dearer than wrought iron girders, inasmuch as they require more than double the weight to furnish equal strength, and even then that cast iron girders cannot be relied on through defects inherent in their manufacture, yet at this very moment we may behold them placed in more than one costly erection progressing in the metropolis, introduced, we suppose, for some consideration for client's whim or builder's convenience. But, although it is a fair subject of inquiry why the use of rolled iron has not received more attention at our hands, it may be stated at the outset that the vast improvement of riveted plate joists and girders over any of the preceding kinds of cast iron or wooden beams in use, and the facilities existing for their construction, justified their retention till it could be demonstrated that a better thing was at hand to replace them.

Few departments of engineering have had the benefit of actual experiments to the same extent as this one of girder construction. Witness the labors of Professor Hodgkinson, Mr. Fairbairn, and others; yet, till recently, we were without any definite knowledge of the properties of the rolled beams and their combinations. Mr. Homan, while engaged in making a series of tests for the purpose of obtaining reliable data for practice, noticed the tendency of all these beams to yield laterally before their full resistance was developed, and sought to obtain the required lateral resistance by riveting a plate on the top flange. Every previous experiment showed that, by supporting the beam back and front in such a manner that it could only yield vertically, the load might be increased 40 per cent. Thus a beam 8 ins. deep, with flanges $2\frac{1}{2}$ ins. placed on supports 20 ft. apart, sustained about 4 tons on the centre before yielding sideways and becoming crippled; while the same beam "cradled," or supported laterally, took $5\frac{1}{2}$ tons before breaking. After the plate had been riveted on the top flange, the same kind of beam took 7 tons without showing the slightest fracture, and merely exhibiting a considerable set vertically. Other results were obtained equally striking. By doubling the depth of a beam, we double the resistance, other things being equal; and so, when increased strength beyond that furnished by one beam was required, it was usual to place two together, either alongside or on each other; for example, if one beam were equal to 4 tons, two beams were equal to 8 tons, and experiment showed that such was actually the case. Two of these beams, 8 and $2\frac{1}{2}$, were, therefore, riveted together, one upon the other, and the lateral deflexion was sought to be remedied as before by riveting a plate, 8 ins. wide by $\frac{3}{8}$ thick, on the top flange. The beam now formed was 16 ins. deep, and it was expected to be equal to 10 tons on the centre, when placed as before on supports 20 feet apart. On applying the strain it was found that 16 tons produced no sensible set, and at 20 tons the beam failed only by lateral twisting,

the iron being sound and uninjured. Here, then, was a novelty. We have examined the various authorities on this subject of beams, and have conversed with several persons who have had great experience in designing girders, without finding any notice or previous knowledge of this singular result; indeed, it is useless to attempt to understand the properties of these girders on any ordinary hypothesis. The real explanation probably lies in the fact that the web-plate, usually considered as not contributing to the strength of the riveted plate girders by reason of the attachment to the flanges being merely mechanical, actually enters into the work of the patent girders, united as it is to the flanges by the superior attachment of the natural cohesion of the metal. Taking, then, the web of these girders as forming an important element in their ultimate resistance, we are able to understand and accept as probable what would otherwise appear extraordinary. In order to arrive at their relative value, compared with the ordinary riveted beam, we will apply the well-known formula of Mr. Fairbairn, $\text{W} = \frac{adc}{l}$, where W = weight, a = area of lower flange, d = depth of girder, l = length, and c is a constant, the value of which depends on the form of beam, and must be ascertained by experiment; whence it follows that the higher the value of c, the greater the value of the beam for the same sectional area. A simple web-plate, with angle-iron on top and bottom, gives a constant of 60; an additional plate on the top and bottom flanges increases it to 75; that is, the strength of the girder is increased in that ratio. A box-beam, or cellular girder, gives a constant of 80, and these respective values are singularly correct when applied to ordinary iron and workmanship; if any deviation is found the cause exists in altered conditions, whether in the quality of the metal or workmanship. We use this formula because it is based on actual experiments, and for years has stood the test of practice; moreover, we understand that it applies with great consistency to the new form of girder. We have said that Mr. Fairbairn's experiments established the values of riveted girders at 60, 75, and 80, the difference depending on their form. The rolled beams made by the Butterly Company give 57 to 88 as constants; the tests we have seen applied to the Belgium beams give higher results; but the difference probably depends on the fact, that the flanges were smaller, and the distribution of the metal such as to enable a larger amount of work to be done in proportion to the sectional area.

Among the experiments recently made at Mr. Kirkaldy's works, we will take two, as best illustrating the subject, and will compare them with the given results of riveted plate girders of corresponding sectional area, and consequently of a like weight per foot run. A rolled beam, 8 ins. deep, with lower flange of $2\frac{1}{2}$ ins., and with a plate 6 ins. by $\frac{3}{8}$ in., riveted on top flange, the whole weighing 22 lbs. per foot run, was placed on the machine at 20 ft. distance between the supports. Now, if we had to design a riveted plate beam of corresponding weight, and if we were seeking the best distribution of the parts, with the view of obtaining the greatest amount of strength, we should make the web-

plate 9 ins. by $\frac{1}{4}$ in. thick, the bottom angles 2 ins. by 2 ins. and $\frac{3}{16}$ in. thick, and the top angles heavier, to equalize the compressive strain of the top flange with the tensile strain of the lower flange, say, 2 ins. by 2 ins. and $\frac{5}{16}$ in. thick. Such a beam, weighing 22 lbs. per foot run, would break with about $3\frac{1}{2}$ tons applied on the centre, with a span of 20 ft. A strain of 4 tons was at once applied on the centre of the patent beam, and after a short time withdrawn, without any appreciable set; 5 tons were then applied, and on being withdrawn a set to the extent of $\frac{3}{10}$ in. was found to have taken place. The load was then increased to 6 tons and 7 tons, the set increasing to 4 ins., but without the least fracture or injury to the beam beyond the set in the centre. If we now apply the formula to find the constant, taking area of flange at 1 in., we have $c = \frac{wl}{ad} = \frac{7 \times 240}{1 \times 8} = \frac{1680}{8} = 210$, and this figure indicates the value of the constant in the formula $w = \frac{adc}{l}$. The second illustration presented was a girder formed of two similar beams, of 8 ins. depth by $2\frac{1}{2}$ ins. width of flange, riveted together, with a plate on the top flange of 8 ins. width by $\frac{3}{8}$ ins. thickness, the whole weighing 40 lbs. per foot run.

For a corresponding sectional area of ordinary riveted girder, we may take a web plate of 12 ins., with bottom angle-irons of 3 ins. by $\frac{1}{4}$ in. thick, and top angles of 3 ins. by $\frac{1}{2}$ in. thick, to equalize the strains as before. Such a girder would weigh 40 lbs. per foot run, and would break with 9 tons applied on the centre. The patent girder was placed at 20 ft. between supports, like the first, and 10 tons weight applied on the centre, without even a perceptible deflexion, although the delicate register of the testing machine showed deflexion, and even set, in an infinitely small degree, when the weight was removed. The weight was then increased successively to 12, 14, and 16 tons, the set registered at this last weight being $\frac{1}{3}$ in., and ultimately increased to 20 tons, when signs of yielding by compression were apparent near the upper part of the web-plate. On attempting to increase the strain it became evident that the girder could not be broken, although by twisting a severe crippling might result. Again applying the formula to ascertain the constant, $c = \frac{wl}{ad} = \frac{20 \times 240}{1 \times 16} = \frac{4800}{16} = 300$, we obtain a constant of 300, against the riveted beam of similar sectional area taken at 75.

The profession will probably desire to see some of these girders tried against girders of the old forms, made of similar iron, and under the same machine, before they admit a great superiority. Enough, however, has certainly been shown to encourage the Messrs. Phillips to persevere in bringing the invention prominently before the public.

On the Performance, Wear, and Cost of Maintenance of Rolling Stock.

By T. A. Rochussen, Assoc. Inst. C. E.

Read before the Institution of Civil Engineers, April 24, 1866.

From the London Civil Engineer and Architect's Journal, June, 1866.

This communication related to the statistics of three Prussian railways—the Cologne-Minden, the Bergish-Maerkish, and the Rhenish—the general circumstances of which were stated to be somewhat similar. The tables embraced the particulars of the engines, and of the carriages and wagons, with the expense of repairs and renewals, the work done by the engines in 1864, the cost of motive power, the repairs and renewals of engine-tyres, and the commercial results. Also the experience of the wear of tyres on the Cologne-Minden Railway for the twenty years, from 1845 to 1864, inclusive, embracing the results of observations upon about twenty-five thousand tyres of different makes and of different materials.

It was stated that, on the Prussian railways, the iron-spoke wheels were gradually replaced by disc wheels, which at first were of wood, but latterly they were entirely of iron. The first form of iron disc, adopted in 1848, was that of a bulged star; a wrought iron plate, flanged to form the periphery of the wheel, was indented with five triangular bugles from the boss, which was cast on the plate forming the disc. This wheel had proved to be very durable, but it was noisy, and, the boss being 11½ inches in diameter, the structure was heavy. It, however, supported the tyre evenly and well, and reference was made to a pair of these wheels with iron tyres, which had run 116,000 miles without requiring turning, and, being still 1⅝ inch thick, it was thought they would last up to 250,000 miles. In 1862, a dished wrought iron disc wheel was introduced, the manufacture of which was both cheap and expeditious. But the fine grain iron necessary to insure a sound flanging for the periphery of the wheel made it too rigid. Attention was then directed to the means of obtaining elasticity both in the form of the disc and in the material used. Accordingly, fibrous iron was employed, and the flat or dished disc was corrugated, the periphery being formed by a rim of fine grain angle-iron, riveted to the disc plate. Subsequently the disc and the rim were welded together, and about the same time the Bochum Company introduced steel castings, in the corrugated form, of combined disc and tyre. In the improved form of the corrugated wrought iron disc, brought out in 1864, the iron used was highly fibrous. Several slabs were forged to the shape of a double cardinal's hat. This bloom was reheated twice, and, by frequent and quick rolling, was enlarged to about three feet in diameter. The rim was welded on under the steam hammer, which, at the same time, punched the hole in the boss for the axle, and gave the form of the wave to the disc plate. After turning up the rim, the tyre was shrunk on and bolted. Since 1864, the tyre, whether of steel or of iron, had been welded on to the disc wheel by hydraulic pressure. In this form, it was believed, the disc wheel offered the greatest amount of strength: the fibrous iron gave elasticity, the tyre was supported

in every part, there were no joints, bolts, or rivets to wear loose, and after the tyre had been worn out, it was simply necessary to turn it down to the thickness of an ordinary wheel rim, and to shrink on another tyre. It was asserted that, with steel tyres, these wheels would run from 300,000 to 500,000 miles before requiring a new tyre, and that by grinding the tyres instead of turning them their life would be prolonged from 50,000 to 60,000 miles.

The Great Forth Bridge.

From the London Mechanics' Magazine, June, 1866.

This bridge has been designed for the purpose of enabling the North British Railway to cross the Firth of Forth between Blackness and Charleston, about fourteen miles west of Edinburgh. On account of the peculiar nature of the bottom, however, before the bridge-works are commenced, an experimental pier will be constructed, which is to be built on a raft as a foundation. This raft, which was launched on June 14 inst., at Burntisland, consists of a mass of parallel logs of Memel timber, bolted together on a series of cross-beams. It is 80 feet by 60 feet, and 7 feet thick, and its superficial area is 4800 feet. The bottom on which this raft will be placed is of silt, which has been bored to the depth of 120 feet. The idea is, that by giving this broad platform or rest to the structure, a secure foundation may be obtained even on that slimy bottom, and on the success of the first pier, so founded, the hopes of the bridge may be said to rest. The raft is intended to be towed to the site of the proposed pier and the building carried on within a caisson, of which the bottom line is already laid upon the raft. Outside the caisson are eight cylinders to be loaded with iron when the raft is sunk. The caisson is trapped with apertures, which will enable the divers to get below the raft for filling up or otherwise perfecting the foundation. The building will be carried upwards from the raft to 12 feet above high water-level, and, the depth being 40 feet, this will give 52 feet of brick-work from the surface of the raft. The greatest diameter of the masonry will be 50 feet, declining to 27 feet, and the thickness 7 feet, the outline resembling the figure 8. The mooring of the raft will be effected by two barges of 700 tons burthen, fitted inside as dwellings for the workmen, and the decks being a platform for materials. After the raft is moored, the masonry will be proceeded with, and as the work goes on and the platform settles down, the walls of the caisson will be carried up, so as to keep out of the water. When the silt is reached by the gradual depression of the raft, the cylinders will be loaded with 10,000 tons of pig iron, about 2½ times the ultimate weight of the bridge upon the pier, so as to press the foundation into the silt, and also to secure a perfectly horizontal position. When the iron load has effected its purpose, the cylinders will be emptied and removed. The Forth bridge, which is designed by Mr. Thomas Bouch, C. E., Edinburgh, and is estimated to cost about half a million, will, should it be carried out, be 2¼ miles long. It will be a lattice girder bridge, resting on 61 piers, and with four spans of 500 feet each, which will be 125 feet above high water-level in the centre.

Each of the four girders will weigh 1170 tons, about 592 tons less than the tubes of the Britannia bridge, though the span is 40 feet greater. The depth of the girders will be 64 feet and the width 18 feet. The height of the bridge from foundation to top of girder will be 212 feet. It is not intended to proceed with any further preparation for the bridge until the success of the experimental pier be fully ascertained.

MECHANICS, PHYSICS, AND CHEMISTRY.

Failure of Chronometers. By Mr. WILLIAM ELLIS, F.R.A.S.

From the London Mechanics' Magazine, June, 1866.

In the course of a lecture on the treatment of chronometers, at the Greenwich Observatory, which was delivered in March last before the members of the British Horological Institute, by Mr. William Ellis, F.R.A.S., the lecturer gave the following as the conclusions at which the Astronomer Royal had arrived with regard to the chronometers examined. They are instructive as pointing out the causes of failure in otherwise unexceptionable instruments. The Astronomer Royal states that the material workmanship of all the chronometers is very good, and amongst nearly all the chronometers there is very little difference indeed in this respect. In uniform circumstances of temperature every one of the chronometers would go almost as well as an astronomical clock. The great cause of failure is the want of compensation, or the too great compensation, for the effects of temperature. Another very serious cause of error is brought out clearly in the trial, namely, a fault in the oil, which is injured by heat. This is very different with the chronometers of different makers. For instance, the oil used by one chronometer-maker is not at all injured by heat; while some of that used by another chronometer-maker is so bad that, after going through the same heating as those of the first-mentioned maker, the rates of the chronometers are changed (on returning to ordinary temperature) by eighty seconds per week. The Astronomer Royal asserts his belief that nearly all the irregularities from week to week, which generally would be interpreted as proving bad workmanship, are in reality due to the two foregoing causes.

When it is considered how very important is the compensation adjustment, it can never be out of place to enforce attention in this particular. Chronometers in which it has not been well attended to cannot come out well in the Greenwich lists, neither will navy chronometers, after repair, pass the Observatory test unless the compensation has been adjusted within close limits. There seems to be a want in London of some establishment to which chronometers might be sent for the purpose of being tested on the same terms as at Liverpool, at which place an observatory has long been established (under the direction of Mr. Hartnup) principally for this especial work. Any person can send a chronometer to the Liverpool Observatory to be tested, on payment of a certain fee; and one feature of the test is a rigorous trial of the compensation. Some such establishment was once started in London, but did not, from some cause, succeed; possibly its existence did not

become sufficiently known. We commend this matter to the careful consideration of the Horological Institute.

For the Journal of the Franklin Institute.

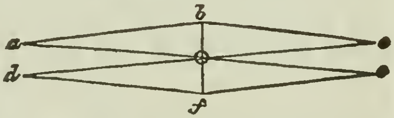
Force and Work. By Fred. J. Slade.

The inquiry of "W." in the June number of the *Journal*, respecting an apparatus for illustrating force, appears to spring from a misapprehension of the distinction between force and work, which, it is believed, is common to many minds, and on that account deserving of attention.

A force may be resolved into components of any magnitude, either greater or less; a given quantity of work, however, can neither be increased nor diminished. Force is a simple element, and may be produced without cost; work, on the other hand, is the product of force and space, and can only be obtained by the expenditure of some equivalent.

Force *alone* produces no effect on bodies; it is only when it is exerted through space, and becomes work, that it effects a change in the state of objects.

This is the distinction that it is important to have clearly in the mind. If, in "W.'s" diagram, we suppose the point o to be acted upon by a force of one pound in the direction o *b*, the points *a* and *c* will each be acted on by a force of 5 lbs.; but if, now, we suppose o to begin to move under the influence of the force, (the force by associating with itself, the element space becoming work,) we see that the agent that is capable of producing this effect will be able and only able to move the points *a* and *c* each through one-tenth the distance in the direction *a* o and *c* o, with five times the force, the product or work done being the same.



So far we have said nothing of moving a weight, because here again there is often confusion of ideas. Work may be performed in a body in two ways; first, by *lifting* it through a certain space; or, secondly, by imparting velocity to it. We cannot speak of moving a body from one point to another in a horizontal direction as a measure of work, since work can only be expended in that case in the production of velocity, and the work performed will, therefore, not be measured by the distance moved through, but by the velocity *imparted* to the body. If the body already have a certain velocity, and that be not increased, it will move through the distance without the consumption of any work.

From what has been said, it will be seen that it is impossible for an amount of work that is only capable of lifting a body through one foot to lift two bodies, each of half the weight, through five times the height; nor, again, if capable of imparting only a certain velocity to a body can it, by any transformation, impart five times that velocity to two bodies of half the weight.

"W." is not the first who has failed to observe the distinction be-

tween force and work. We have known of a whole life-time being expended in the persistent effort to develop an invention based on this error, the inventor, though apparently a man of considerable study, being unable, from long habit of thought, to perceive his mistake when pointed out to him.

Mr. Hicks' Experiments on the Friction of Leather Collars in Hydraulic Cylinders.

For the Journal of the Franklin Institute.

An interesting paper in the June number of the London *Engineer*, details the experiments of Mr. John Hicks, C. E., and of Mr. Lüthy, an assistant engineer in his employ, to determine the friction of the leather collars or cup packing used in hydraulic presses. Very little has ever been published on this subject, and some gauges for high pressure have been made in which a plunger, packed in the usual manner, is used, in connexion with certain spring balances, to indicate the amount of pressure; and in these gauges the friction of the collars has been ignored. The instrument used by Mr. Hicks in prosecuting his investigation was one made with great care, and was capable of experimenting with plungers of various diameter, say from half an inch diameter up to 8 inches diameter. The testing plunger was made to pass through two packing rings of the same size, the pressure occurring between the rings. The plunger was thus balanced and could be moved back and forth with more or less ease, in proportion to the decrease or increase of the frictional resistance for the pressure of the fluid upon the packing rings. The experiments have been published in full, but we will only detail the

Result from the Experiments.—"The friction increases as the pressure increases. The frictions of the leathers for rams of different diameters, if the pressure per unit of area be the same, increases in direct proportion with the diameter, or with the square roots of the respective bolts.

"The depth of the leather does not affect the frictions on the ram." This latter assertion seems to have been made after quite a series of experiments had been tried with leathers of different depths, and the conclusion arrived at that "the whole friction is produced just where the leather emerges from the hollowed part of the groove and begins to lean against the ram."

From the experiments they have deduced the following formula:

$F = D \times P \times C$ in which P = pressure per square inch; C = a co-efficient = 0·0471 if leathers are new or badly lubricated, or = 0·0314 if leathers are in good condition and well lubricated, and D = diameter of ram.

Where pressure per circular unit is given, the formula remains the same as the co-efficient C = ·06 for bad lubrication and ·04 for good.

The annexed table gives, in a compact form, the frictional resistance in per centage of the total hydraulic pressure for rams from 2 inches up to 20 inches diameter.

D inches.	F per cent.	D inches.	F per cent.
2	2·00	11	0·38
3	1·33	12	0·33
4	1·00	13	0·30
5	0·80	14	0·28
6	0·66	15	0·26
7	0·57	16	0·25
8	0 50	17	0·23
9	0·44	18	0·22
10	0·40	19	0·21
...	...	20	0·20

In the above, the friction on a ram 4 inches diameter is given as one per cent. of the gross load.

In forty-eight experiments the friction varied from one per cent. to 0·5 per cent., variation being ½ per cent.

In some experiments made in this city by Messrs. Wm. Sellers & Co., in hydraulic testing machines, they used as a gauge a steel plug, half an inch diameter, fitting into a steel collar of the same size. The collar in which the plunger moved freely was 3½ inches long, and this length of bearing was found sufficient to prevent the escape of oil under the pressure of 5000 lbs. to the square inch. They adopted this expedient for dispensing with packing from their knowledge of the variable frictional resistance of the leather collars.

They found, however, that although all packing was dispensed with, yet as the pressure increased a frictional resistance became manifested. It is now a matter of interest to determine, in a manner similar to the plan of Mr. Hicks, what is the rate of increase in frictional resistance, with plungers depending for their tightness, not upon packing, but upon long closely-fitted joints.

The Smithsonian Institute on the Ice on the Strainer.

In reference to an article published in the May number of this *Journal*, we publish the following as embodying the opinion of a competent authority. We think, however, that the views of Mr. Douglass are undoubtedly correct, and the hypothesis given by Prof. Henry, as of Arago, is insufficient to account for the facts:

University of Michigan,
(Department of Chemistry.)
Ann Arbor, *June* 13.

To the Editor of the Detroit Free Press:

The discussion of the subject of the accumulation of ice on the strainer at the water-works will be recollected by many of your readers A few days since I received the following letter from Prof. Henry, the distinguished physicist at the head of the Smithsonian Institution:

Smithsonian Institution, *May* 17, 1866.

My Dear Sir: In looking over the *Journal of the Franklin Institute* for the present month, I find your letter relating to the freezing of water around the mouth of an iron pipe at the depth of twenty-five feet below the surface. The fact is interest-

ing as a striking example of the production of "ground-ice," the explanation of which has been a puzzle to the physicist. The explanation which you have given is that which most readily suggests itself to those familiar with the experiments of Dr. Wells, and, indeed, is that which was most generally adopted previous to the researches of Melloni. He has shown that terrestrial radiation or heat of low intensity, is interrupted by the thinnest sheet of water. It is true, that the more intense rays of heat from the sun penetrate to a considerable distance below the surface of still water, but the less intense rays do not enter the water to any depth, and it is probable that by far the greater portion of a beam of solar radiation is stopped at the surface of water. Ground-ice is formed at the bottom of streams of running water, adhering to stones, grass, or other solid bodies. The explanation given. I think by Arago, is as follows: The water at the surface is cooled down below the point of congellation, when, by the motion of the water in the stream, it is brought into contect with a solid body at the bottom, which, acting as a nucleus of crystallization, immediately determines its solidification. This explanation will apply equally to the case referred to you, in which the water from the surface is drawn down by the discharge from the pipe. I think it probable that the whole subject requires further elucidation, and it is on this account I have taken the liberty to direct your attention to the facts I have stated.

JOSEPH HENRY.

PROF. DOUGLASS, University of Michigan.

The experiments of Melloni, as well as the explanations of Arago, of the formation of "ground-ice," I was familiar with at the time I gave my views last winter, but deemed them inadequate to the explanation of the singular phenomena, for the following reasons:

First. At 39·2° of temperature water has its maximum density. This is about 7° above the freezing point. The cooling takes place at the surface. and as the temperature arrives at 39·2° the cooled water would, by virtue of its diminished specific gravity, remain at the surface. I can scarcely conceive that the current of Detroit River, or the discharge from the pipe, would be sufficient to cause the water to descend twenty-five feet against the force of gravity.

Second. Why is it the ice ceases to form on the strainer as soon as the river is covered with ice, unless it is because the ice intercepts the radiation?

Prof. Henry is probably not aware of the moderate current of the river, or the fact last mentioned.

I send you the above letter from the distinguished Professor, that the public may know the intense interest that scientific men feel in the solution of this mysterious problem. I cannot but express the hope that the Water Commissioners will take measures to test the truth of these theories the coming winter.

S. H. DOUGLASS.

On Magnetical Errors, Compensations, and Corrections, with special reference to iron ships and their compasses. By Professor AIRY.

From the London Athenæum, April, 1865.

Prof. Airy has given three lectures "On Magnetical Errors," &c., at the old lecture theatre of the South Kensington Museum. These lectures were of so much importance as to deserve the utmost publicity.

The subject was treated under the following heads: I. Terrestrial magnetism and the magnetism of permanent magnets. II. Transient induced magnetism of iron. III. Sub-permanent magnetism of iron. IV. Correction of magnetic disturbing forces. V. Magnetism of ships, especially of iron ships, and correction of their magnetic disturbing forces on the ship's compass.

From the Professor's notes we give the following synopsis:

I. *Terrestrial Magnetism and the Magnetism of Permanent Magnets.*—1. Every magnet has two opposite poles, possessing different properties.

2. Every bar-magnet, when freely suspended, takes a definite position, one end pointing to the magnetic north. (The end which points

to the north is usually called the "marked end;" in the magnets used in the illustration of the lectures, it will be distinguished as the end painted *red*, the opposite end being painted *blue*.) In the following articles the words "north" and "south" are always understood as meaning "magnetic north" and "magnetic south."

3. The force which directs a magnet is not simply a force attracting the marked end towards the north horizon, or a force attracting the unmarked end towards the south horizon; but, if it consist entirely of attraction, is composed of equal attractions of those two kinds. It may consist, wholly or in part, of repulsion of the marked end from the south and repulsion of the unmarked end from the north; but if so, those repulsions are equal. Or, the north part of the earth may attract the red end and repel the blue with equal forces; or the south part of the earth may attract the blue and repel the red, but the forces must be equal. This is proved by the fact that the magnet, as a whole, is not drawn north or south.

4. The direction of one end of a freely suspended magnet towards the north will be used as the practical definition of the marked end of a magnet.

5. The marked end of one magnet repels the marked end of another magnet, whether it be presented sideways or endways. In like manner, the unmarked end of one magnet repels the unmarked end of another. But the marked end of one attracts the unmarked end of another, and *vice versa*. When a magnet cannot be conveniently suspended, this property may be used, with the assistance of another suspended magnet or compass, for distinguishing the blue and red ends. The points in which the attractive and repulsive powers appear to be concentrated are called the "poles of the magnet." It may be understood, without great inaccuracy, that the distance of each pole from the end of the magnet is about one-twelfth of the whole length.

6. A horse-shoe magnet is merely a bent bar-magnet, with poles possessing the same properties as those of a straight bar-magnet.

7. If above a large freely suspended bar-magnet a small magnet be freely suspended, when it is raised high it takes the same position as the large magnet; when it is lowered near to it it takes the opposite position, and at a certain intermediate height it is indifferent as to position, no force (apparently) acting on it at all.

8. These observations show that the magnetic attraction of the earth is similar in character to that of a bar-magnet, but that the part of the earth which resembles in its magnetism the marked or red end of a magnet is on the south side of the place of observation.

9. General principle of ascertaining the relative magnitudes of forces by vibrations of a suitable apparatus. The relative magnitudes of the terrestrial horizontal magnetic forces at different parts of the earth may be ascertained by observing the vibrations of the same magnet at different places. The forces thus found vary very greatly, being large near the irregular line called the earth's magnetic equator, and becoming insensibly small near the places called the magnetic poles of the earth.

10. In the preceding articles it has been supposed that the magnet

is constrained, either by the nature of its mounting or by the application of weights, to preserve a horizontal position, as it ought to do, in compass-cards, (the idea of allowing their needles to dip being totally erroneous.)

11. If the magnet is perfectly free, as in the instance of a dipping-needle, it takes a position inclined to the horizon; the marked end of the magnet is greatly depressed, pointing, at Greenwich, 68° below the north horizon, or much nearer to the vertical than to the horizontal direction. The direction thus taken by the free magnet is called "the direction of dip," and the plane perpendicular to it is called "the equatorial plane." (This "equatorial plane" is carefully to be distinguished from "the earth's magnetic equator," Article 9.)

12. Anticipation of the section on induction. Magnetization of a bar, or a reversion of its poles, by "double touch."

13. It is made certain, by reversing the poles of the dipping-needle, that the dipping is not produced by want of balance of the needle, but is a real result of the inclined direction of terrestrial magnetism.

14. At Greenwich, it is inferred from the direction of the dipping-needle, that the horizontal part of terrestrial magnetic force is less than the vertical part in the proportion of 40 to 99, that it is less than the whole inclined force in the proportion of 3 to 8, and that the vertical force is less than the whole inclined force in the proportion of 51 to 55; all very nearly.

15. Exhibition of the dips in different parts of a meridian of the earth. At the magnetic poles the dip is vertical, and there is no horizontal force. At the magnetic equator there is no dip. South of the magnetic equator the unmarked end of the needle dips. The magnitude of the total inclined force is rather less near the equator than in other parts of the earth, (it may be stated roughly as one-half of that near the magnetic poles,) but it is entirely effective in the horizontal direction.

16. Disturbance of a suspended magnet by a magnet placed below it. When the lower magnet has its marked end to the north, the directive force on the upper magnet is diminished; and when the lower magnet has its marked end to the south, the directive force on the upper magnet is increased, as is shown by its times of vibration.

17. If the lower magnet is made to rotate in a horizontal plane the position of the upper magnet is disturbed. During half the rotation the marked end of the upper magnet is turned somewhat to the east, and during the other half it is equally turned towards the west. The deviation vanishes when the lower magnet lies north and south, either way. The direction of disturbance is that given by the repulsion of similar poles or the attraction of different poles. This disturbance is sometimes called "semicircular deviation."

18. It is important to ascertain how this semicircular deviation will vary in different parts of the earth, (where, as stated in Article 9, the magnitudes of the terrestrial horizontal force vary greatly,) supposing the same lower magnet to be used, and at the same distance from the upper magnet.

19. Recourse must be had to the mechanical theory of "the com-

position of forces," the most important theory in the whole circle of sciences, and with which every student of any philosophical subject ought to be perfectly acquainted. Theorem of the "parallelogram of forces."

20. If with a primary force (as the terrestrial horizontal magnetic force acting on either pole of a magnet) there be combined a new force in a different direction, (as the force of the lower magnet acting on the same pole,) the direction of the resultant force will deviate from the direction of the primary (or terrestrial) force. But the greater is the primary force the smaller is the deviation. Thus, if a ship carries a magnet under or near her compass, this magnet will produce but a small deviation when the ship is near the terrestrial magnetic equator, (where the terrestrial horizontal magnetic force is large,) but will produce a great deviation in high magnetic latitudes, (where the horizontal magnetic force is small.)

21. If the lower or second magnet be not immediately below the upper or first magnet, but be on one side, whether at the same level or not, being, however, in the position "broadside on," and if its supporting frame rotate round the vertical axis of the first magnet, the deviation which it produces is semicircular, (see Article 17,) and vanishes when the second magnet lies north and south. The same holds when the second magnet is "end on." But if the second magnet is in an intermediate or inclined position, the deviation is semicircular, but the vanishing of the deviation occurs when the second magnet lies in a position varying from north or south.

22. But, supposing the second magnet to be lower, there is one important difference of these actions. If the first magnet is free to dip, then a second magnet broadside on will not cause the first magnet to dip, but a magnet end on, or nearly end on, will cause the first magnet to dip.

22*. The proportion of the actions of one magnet on another may be calculated with great accuracy by considering each magnet to consist of two centres of force (attractive or repulsive) near its extremities, acting on the similar centres of force of the other magnet, with equal force in all directions, varying inversely as the square of the distance. It results from this that, in any given direction of the line joining their centres, the directive force of one needle upon another varies nearly as the inverse cube of their distance.

23. The "astatic needle" is made by fixing two magnets of equal power on different parts of the same frame, with marked ends in opposite positions. The united frame is then insensible to terrestrial magnetism, but either magnet separately will be affected by the local action of a magnet near it.

23*. The astatic needle may be used to exhibit strikingly the effects of one magnet on another. Thus, if the external magnet be below or at the side of the lower needle of the astatic pair, the latter takes an opposite position as regards red and blue ends; but if the external magnet be moved, without change of direction, so as to present an end to the lower needle of the astatic pair, the latter immediately turns so as to take a similar position as regards red and blue ends.

II. *Transient Induced Magnetism of Iron.*—24. If a soft iron bar, which has not been subject to any special violence, be presented endways to the centre of a freely suspended magnet, the direction of the iron bar being either east or west in the horizontal plane, or any direction included in the equatorial plane, (see Article 11,) then no deviation whatever is produced in the magnet. If it be presented endways to either pole of the magnet, it slightly attracts that pole, (a fact to be explained below, Article 26.) It is indifferent which end of the iron bar be presented.

25. If a second magnet, with an iron bar in front, but separated by a small interval, be presented to the first magnet, and deviation be thus caused, then, upon causing the iron bar to touch the second magnet, the deviation of the first magnet is immediately increased, decreasing again when the iron is separated from the magnet. This shows that the contact of the second magnet has converted the soft iron, for the time of contact only, into a magnet whose poles are in the same relative position as those of the second magnet; and therefore a red pole of the second magnet produces a blue pole in that part of the iron which is next it, or *vice versa.* This production of magnetic power in iron by the action of an external magnet is called "induction."

26. This explains the attraction of soft iron by either pole of a magnet. For the magnet-pole, by induction, produces a pole of the opposite character in the nearest part of the iron; and between poles of opposite character there is attraction, (Article 5.)

27. If a bar of soft iron be held in a vertical position, then, upon raising and depressing it, it is found that the end which is lower repels the red end of the magnet and attracts the blue end, and the end which is higher attracts the red end of the magnet and repels the blue end. The bar has become a genuine magnet with red end downwards. But this magnetism is only transient; for upon inverting the iron bar the properties of its ends are inverted, and if it is placed in the equatorial plane (Article 11) they vanish entirely.

28. This is explained by induction produced by the powerful terrestrial magnetic force in the vertical direction, (Article 14.)

29. The amount of action depends, in some degree, upon the connexion of the parts of the mass of iron. The same mass in the same general form, but divided into several parts, produces a smaller effect.

30. If a mass, as a cannon-ball, be made to rotate round the suspended magnet in the same horizontal plane, it produces no disturbance when it is north, or south, or east, or west of the magnet's centre; but in the intermediate quadrants it produces deviation, changing its character in every successive quadrant, which may be represented (in memory) by saying that "the mass attracts that pole of the magnet which is nearest to it." This is called "quadrantal deviation."

31. The explanation is, that the induction produced by the horizontal part of terrestrial magnetic force converts the mass of iron into a horizontal magnet with red pole always towards the north. (A small magnet carried round always in that position produces a similar effect.) It is to be remarked, that the induction produced by the vertical part

of terrestrial force does not appear here, for a small vertical magnet carried round in the same manner produces no effect.

32. It may here be noticed that the quadrantal deviation thus produced in the compass by a mass of iron in the same horizontal plane is the same in all parts of the earth. For, referring to the parallelogram of forces, (Article 19,) if the "primary force" (which is here the terrestrial horizontal force) and the "new force" (which is here the force of the magnetism induced in the mass of iron) be always in the same proportion, the deviation for any definite inclination of the two forces is unaltered. Here they always are in the same proportion; because the magnetism in the iron, which is induced by the earth's horizontal force, is proportioned to it.

33. If the cannon-ball is higher or lower than the magnet, the deviation vanishes when it is north or south, but not when it is east or west, exhibiting a mixture of semicircular deviation (Article 17) with quadrantal deviation, (Article 30.) The former is produced by induction from the vertical part of the terrestrial force; it is exactly similar to the effect of a small vertical magnet (with red pole downwards, and with centre higher or lower than the deviated magnet) carried round the deviated magnet. The latter has been explained above, (Article 31.)

34. On further examination, it is seen that all effects are explained by induction in the cannon-ball, produced by the total terrestrial action in the direction of dip, converting the cannon-ball for the time into a magnet whose red end points down in the direction of dip.

34*. The law of disturbance may thus be represented (from memory). Through the centre of the magnet conceive an equatorial plane (Article 11) to pass. The mass of iron attracts that end of the magnet which is on the same side of the equatorial plane as itself.

35. Since the induced horizontal magnet (Article 31) has its red end in a position opposite to that of the earth, (Article 8,) it follows that one effect of the proximity of such a mass of iron at a lower level than the deviated magnet is, on the whole, to somewhat diminish the directive power of terrestrial magnetism.

36. The ordinary process of magnetizing a steel bar by double touch of two permanent steel magnets is a process of induction, differing from those of soft iron only in this respect, that the steel bar, when it has received the magnetism, retains it permanently.

III. *Sub-permanent Magnetism of Iron.*—37. When a bar or plate of soft iron, in a state of tremor from mechanical violence, is exposed to external magnetic action, it receives induced magnetism in the same manner as iron in a quiet state, (Articles 27 and 34;) but the induced magnetism is much more powerful, and is for a long time sensibly permanent. It does not change its direction on changing the position of the bar, (as in Article 27,) and it does not vanish in any position of the bar. The iron bar has become a true magnet, exactly similar in its action to a magnetized steel magnet. Its magnetism, however, diminishes sensibly in a few days or a few weeks, but a portion remains for many months or years. This has been called "sub-permanent magnetism."

38. The sub-permanent magnetism is most easily produced by striking an iron bar or plate under the action of terrestrial magnetism. The "magnetic anvil," consisting of two planes, one containing the direction of local dip, the other being the equatorial plane, (Article 11.)

39. If a bar or plate be placed on the dip-slope of the magnetic anvil, with its white end downwards, and be struck with a hammer, it becomes a powerful magnet, the white end having the properties of a magnet's red end, and the black end having the properties of a magnet's blue end.

40. If, now, it be reversed on the dip-slope with black end downwards, and be struck in the same manner, the black end has the properties of a magnet's red end, and the white end has the properties of a magnet's blue end, the power of the magnet being sensibly equal to what it was before.

41. If the bar, thus charged with sub-permanent magnetism, be placed on the equatorial slope of the magnetic anvil, and be struck in the same manner, all magnetism will sensibly disappear.

IV. *Correction of Magnetic Disturbing Forces.*—42. It is impossible to intercept the action of magnetic disturbing forces upon a magnet or compass by surrounding the compass, &c., with any substance whatever. Nothing is known which interrupts magnetic action, and if such a substance could be found, it would also interrupt terrestrial magnetic action, (which is of the same nature as the action of a magnet, see Article 8,) and the compass, &c., would be useless.

43. The only way of destroying the effect of one magnetic disturbing force is, to introduce another magnetic disturbing agent, whose force follows the same laws and has the same magnitude, but always acts in the opposite direction.

44. The disturbing effect of one magnet, or of several magnets, supposed to rotate round the compass, &c., in a horizontal plane, may be corrected by one magnet, or sometimes, more conveniently, by two magnets.

45. The disturbing effect of a mass of iron at the same level as the compass, which is quadrantal, (Article 30,) cannot be corrected by an equal mass on the opposite side; such an application would double the disturbance.

46. But it may be corrected by an equal mass at the position 90° distant, or by two smaller masses 90° distant each way, (and therefore opposite each other.)

47. It may also be corrected by placing another compass near to the disturbed compass.

48. The disturbance produced by an elevated or depressed mass of iron can be corrected by applying an equally elevated or depressed mass on the opposite side, which corrects the semicircular deviation, (Article 33,) but doubles the quadrantal deviation, (Articles 30 and 45,) together with a large mass 90° distant, or two masses 90° distant on each side, (either of which arrangements may be made to correct that doubled quadrantal deviation, see Article 46.)

49. Or it may be corrected by using a small magnet to correct the

semicircular part, (the small magnet being adjusted by trial to make the disturbance disappear when the mass is east or west,) and then applying a small mass or two masses 90° distant to correct the quadrantal part.

50. There is inconvenience in effecting, by a magnet, the whole or a part of the correction of a disturbance produced by terrestrial induction in masses of iron, (as is proposed in Articles 47 and 49,) because the action of the magnet is the same in all parts of the earth; whereas the disturbing force produced by induced magnetism in iron is proportional to the terrestrial force, which varies in different parts of the earth, (Article 9,) and whose direction relative to the horizon is in some places nearly inverted, (Article 15,) and thus the correction cannot be made universally effective.

51. The correction of the disturbing force of induced magnetism in one mass by the force of induced magnetism in another mass, (as is proposed in Articles 46 and 48,) is theoretically perfect in all parts of the earth, because both the disturbing force and the correcting force are proportional to the terrestrial force, and therefore they neutralize each other whatever be the magnitude and direction of that terrestrial force. This applies accurately to action on points near the centre of a compass, or applies very nearly to action on all points when the compass is small.

52. When the compass is large and has only one needle, the correction produced by a small mass of iron is not perfect, because it must be brought so close to one pole of the needle that the action on that pole is unduly large. But this inconvenience is almost entirely removed by use of the Admiralty compass with four parallel needles.

53. When the only correction to be effected is that of a quadrantal deviation, (Articles 30 and 45,) it may be abandoned entirely, provided that a compass-card with modified graduations be used; because the quadrantal deviation is the same in all parts of the earth, (Article 32,) and therefore the same modification of the compass-card which correctly alters the apparent card-reading in one part of the earth will correctly alter it in every other part.

(To be continued.)

Explosion of Steam Boilers.

From the London Mechanics' Magazine, April, 1866.

No. 7 explosion, by which one man was killed and five others injured, is an illustration of the unsatisfactory and dangerous character of plain cylindrical externally-fired boilers. This subject has frequently been called attention to in previous reports, but it is felt to be a duty to continue to do so as frequently as fatal explosions recur from the continued use of this class of boiler. The explosion in question took place at about quarter past ten o'clock on the morning of Monday, January 29, at a colliery which was not under the inspection of the Association. The boiler was about 30 ft. long, 6 ft. in diameter, and made of plates laid longitudinally, and $\frac{3}{8}$ in. in thickness,

while the safety-valves were loaded to a pressure of a little more than 40 lbs. on the square inch. The boiler gave way, in the first instance, for a length of 5 ft. in a longitudinal direction, at a seam of rivets over the fire, the rent then developing transversely on each side of this primary longitudinal one, stripping from the shell an entire belt of an average width of about 6 ft., and thus separating the boiler into three pieces, one of which, about 21 ft. long, was thrown to a distance of 210 yards from its original seat. The cause of this explosion was not shortness of water. The boiler was twenty-five years old, though it had not worked the whole of that time, being idle from 1844 to 1852. It was fed with sedimentary water drawn from the pit, but had no sludging or blow-out apparatus, either at the bottom of the boiler or the surface of the water, for removing the deposit. The plates over the fire had suffered and been repaired, while the primary rent had occurred in this instance at one of the old plates, and through a seam of rivets uniting it to the new work. There is, therefore, no difficulty in determining the cause of this explosion, and all boilers working under similar conditions are highly dangerous. In putting new plates into these boilers, the work is frequently so strained that they are weakened instead of being strengthened by repairs, and in most cases, at all events, it is impossible to detect this simply by examination, however careful, after the work is completed. This is just one of the reasons that makes this class of boilers so dangerous, and which is illustrated by the fact that the boiler in question is reported to have been examined on the Friday and Saturday before the explosion, when it is to be presumed it was passed as safe, or steam would not have been got up in it. On these grounds it is trusted that it will be seen that the recommendation is not given without good reason, that boilers of this treacherous, plain cylindrical externally-fired construction should be discarded for those fired internally, which are much more reliable.

Steam Boiler Explosions.

From the London Mechanics' Magazine, November, 1865.

Notwithstanding the horrible list of deaths and mutilations from steam boiler explosions which every year, nay, every month, produces, there appears to be little or no increase in care and circumspection in these matters, and, as a consequence, no diminution of catastrophe. If accidents from this cause are not on the increase they certainly are not on the decrease, nor can they be expected to decrease while carelessness, indifference, and parsimony prevail. The two chief evils accompanying the use of boilers are recklessness and incompetency, and these are at the bottom of most accidents. If we take up the monthly reports of the Boiler Insurance Engineers, we rarely find explosions accounted for by any other than circumstances of the most culpable neglect or the grossest ignorance and inefficiency on the part of those in charge. Often, too, does the parsimonious spirit of the proprietor lead to disaster, when he higgles and bargains about a new boiler. He cuts down the price below the figure at which a respectable

house will take the job; he, however, gets it done—by whom and how only occur to him when a coroner's inquest is sitting. But parsimony does not stop at the boiler; the attendant is bargained with and beaten down for a few shillings a week, and sheer ignorance often goes to take charge of an explosive machine which the greatest care and knowledge alone should control. But it is the old story, and some men never seem to know that if they want a good article they must pay a fair price for it, and that a respectable maker's name, whether on a boiler or a coat, is the best guarantee for its wear. Of course, this assumes proper use; a coat will soon be shabby by careless usage, and a boiler will as soon deteriorate if badly tended. Two cases in point occur in Mr. Fletcher's last report to the Committee of the Manchester Boiler Association, one having reference to neglect, the other to incapacity, and both involving parsimony. The first case was the explosion of an ordinary Lancashire mill boiler, having two furnace tubes and being internally fired. Its length was 30 ft. 6 ins., its diameter in the shell 8 ft. 2 ins., and in the furnace tubes 3 ft. 1 in., while the thickness of the plates varied from $\frac{3}{8}$ in. to $\frac{7}{16}$ in. in the shell, and was $\frac{7}{16}$ in. in the furnace tubes. The ordinary working pressure was about 40 lbs. on the square inch, which is not too high for this class of boiler, if well made and well kept.

The boiler was a mere wreck, and the premises were seriously damaged. We need hardly add that there was loss of life and injury. There could be no question as to the cause of the explosion: the flues were not faulty, and there were no signs of overheating of the plates through shortness of water. The explosion simply arose from the rupture of the shell in consequence of the plates being reduced in many places by external corrosion to the thickness of a sheet of paper. The boiler was a cheap one in the first place, and had been at work about eight years; there was constant leakage, constant repairing, and constant administration of a dose of horse-dung. Of course, the story was that this medicine was for the water and not for the boiler—to soften the former, not to stop the leaks in the latter. But considering the condition of the shell, and the general purpose for which horse-dung is put into boilers, it is not hard to assign the true function to the dose which was given after every cleaning. What makes this case worse is the fact that the boiler was well known to be in an unsatisfactory condition, so much so that a boiler-maker had been in negotiation to replace it by a new one last Whitsuntide. But probably the proprietor, mindful only of pelf, could not bring the boiler-maker to his terms, and so resolved to use the old kettle a little longer to balance matters. However this may be, and whatever may have been the qualifications of the attendant, this certainly was a case of the most flagrant neglect, and one which could not have occurred under competent inspection.

The second case occurred with a converted marine boiler, of the steam-tug class of construction. It was a second-hand affair, and had seen some service afloat before it was set to do duty on land. The shell was cylindrical and internally fired, but the flue, instead of go-

ing straight through from the front to the back, as in the ordinary Cornish boiler, returned in a horse-shoe shape to the front end, and passed out through the bottom of the shell into an underneath brick-work flue leading to the chimney. In steam vessels the return flue of these boilers passes out through the top of the shell by means of an uptake, on which the funnel is planted. In adapting this boiler for its new work, however, this uptake had been removed and exchanged for the downtake leading to the brick-work flue above referred to. The boiler was about 13 ft. long, 5 ft. 6 ins. in diameter, and the plates generally about $\frac{3}{8}$ in. thick. Here was a boiler badly constructed, badly used, and badly tended, a boy only fourteen years of age having been *appointed engineer* a few hours before the explosion occurred by which he was killed. Comment is surely superfluous here. The poor little fellow, in his ignorant anxiety to get up steam, had only lashed *three bricks* on to the lever of the safety-valve, in addition to the ordinary ball weight! The actual load amounted to 100 ℔s. per square inch on the crazy old concern. The pressure does not appear to have reached this point, however, for it is stated that the gauge only registered 50 ℔s. a minute or so before the explosion. But the boiler was so badly constructed that even this pressure was quite sufficient to account for the explosion, as may be inferred from the fact that the return flue tube was oval in shape, measuring 2 ft. 6 ins. vertically, and 1 ft. 4 ins. horizontally. This form is weak, and in fact any departure from the cylindrical in furnace and flue tubes materially impairs their strength, if the difference is only 2 ins. In the present instance, the flue departed as much as 14 ins. from the circular shape, and, besides this, was not of a true oval, but was flat or wall-sided for a height of 18 ins. from end to end. The form of the downtake also was weak, one side presenting a flat surface of 2 ft. 6 ins. square, the plate at that part being only $\frac{5}{16}$ in. thick. In short, the boiler was utterly unfit to drive a non-condensing engine at a pressure of 40 ℔s. or 50 ℔s. per square inch, although it might have jogged on for a time, with a condensing engine, at 20 ℔s. pressure. What with the weak construction of the boiler and the way in which the safty valve was overloaded, there is no difficulty in accounting for the explosion.

The question which naturally arises is, How many of these rickety, badly-tended machines are there about us, and where will the next mine be sprung? That there are such there can be no doubt; their whereabouts may only be developed by the coroner's inquest, when it again sits on a few more atoms of parboiled humanity. It is an outrage upon society that men should not only be allowed to place these engines of destruction in our midst, but that they should be under no responsibility as to the tending of them. If no sense of moral obligation exist, it is time for authority to interfere and enforce those conditions which the well-being of the country demands. We cannot conclude without referring to the ignorance manifested by some boiler-makers. This is especially observable in the case of the explosion last alluded to, where the maker, who converted the boiler from a marine to a stationary, could not account for the explosion, neither could a second maker,

by whom it had been repaired, and considered perfectly safe. The hydraulic test—the general adoption of which is so much to be desired—was not applied at the time of the alterations, or the weakness of the flat-sided flue would have been apparent and the explosion averted. But the best constructed boiler could never stand such a reckless overloading of the safety-valve as that above recorded. If owners will not learn the lesson of responsibility of themselves, they will have to be taught it in a way the least palatable to liberty-loving Englishmen.

Description of an Equatorial Clock. By Lord Oxmantown.

Monthly Notices Royal Astronomical Society, May, 1866.

The following description of an apparatus for giving an equable motion to a heavy equatorial of 18 inches apperture may, perhaps, be interesting to some of the Fellows.

It was constructed last autumn, and its merit, if it has any, is that it can be very easily made. No nice workmanship is required; a joiner and plumber can execute the work with sufficient accuracy.

The motive power is a piece of wood, closely fitting a wooden box containing water, on the surface of which this piece of wood floats. This float is covered with canvass, saturated with pitch, to prevent it from imbibing water, and so expanding and sticking fast in the box.

It has, also, pieces of sheet-brass fastened on the edges over the pitched canvass, to prevent the pitch adhering to the sheet-lead with which the box is lined. A tube from the bottom of the box, terminating in a piece of flexible pipe, the extremity of which is kept at a uniform depth below the surface of the water in the box by being suspended from the float, allows the water to escape at a constant rate, which is regulated by a valve in this pipe. *h h* is the box; *i i* the float, which is attached to a brass tube *d d*, which acts as a guide by passing through a hole in the cross-piece of wood *ff*, supported by two upright pieces *g g*; *n n* is the India-rubber tube, through which the water escapes; *o* the valve to regulate the flow; *m* is a cock, which is closed when the clock movement is not required; *q q* a second box to receive the water as it flows out of the first. When we wish to employ the clock, we first pump up water from *q* to *h* through *p* and *l*; secondly, we get the object to be observed into the centre of the field; thirdly, open the cock *m* and clamp the sector *t* to the polar axis *z* by means of the screw *u*; and if the object is not now sufficiently in the centre of the field, it may be brought there accurately by turning the nut *c*, which draws the sector *t* further or near to the float, by bending the spring *w*.

The accuracy of this clock depends, to a great extent, upon the care which is taken to make the sides of the box parallel and flat, so that the horizontal section may be the same at all levels, and to fit the float to it carefully, so that the interval between the float and the sides of the box may be as small as is consistent with absence of friction. Let A be equal to the area in square inches of horizontal surface

of float, and $\frac{A}{n}$ area of interval between the float and sides of the box; then, if the float be displaced $\frac{1}{m}$th of an inch from the position of equilibrium, the surface of the water round the float will be displaced through $\frac{n}{m}$ inches; therefore, if $w =$ weight in lbs. of 1 cubic inch of water, the force tending to bring the float back to its former position $= w \cdot A\left(\frac{n}{m} + \frac{1}{m}\right)$; whereas, if the float had rested on a surface of water of infinite extent, the corresponding force would have been $w \cdot A \times \frac{1}{m}$; $\therefore$ the ratio of the forces in the two cases $= n + 1 : 1$. In the case of the instrument to which this apparatus has been applied, $A = 1296$, and if, for example, the interval between the float and sides of the box $= \frac{1}{16}$ of an inch, and if the variation of friction of the polar axis be taken at 3 lbs., (the average friction being about 7 lbs.,) the displacement of the float, which would have been equal to ·064 of an inch on a surface of water of infinite extent, will become equal to

$$\cdot 064 \times \frac{1}{1 + \frac{36^2}{4 \times 36 \times \frac{1}{16}}} = \frac{\cdot 064}{145} = \cdot 00044 \text{ inches.}$$

As the float is attached to a wire rope, the other extremity of which wraps round the sector *t*, of 28 inches radius, this deviation corresponds to 7′ 51″ of space in the first case, but only 3′·2 in the second case.

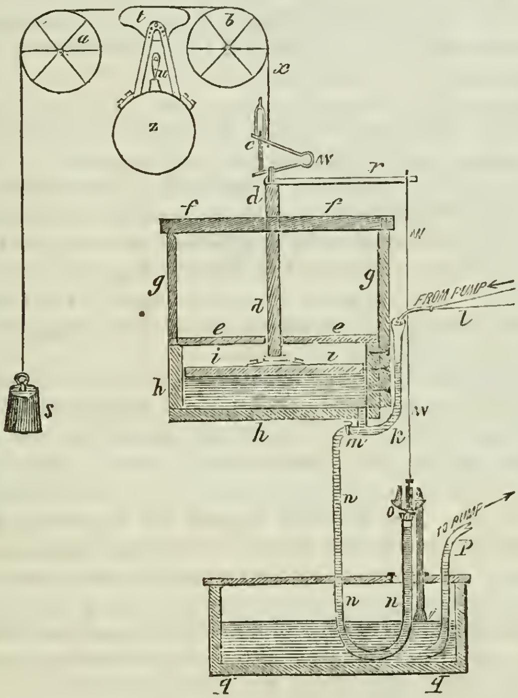
Assuming that the flow of the water from the box will be uniform if the head be uniform, the only remaining cause of irregularity lies in this, that the overflow is kept at a constant depth below any fixed point in the float, that point, through variation of the resistance, not being at an absolutely invariable distance below the surface of the water in the box; consequently, the head will vary if the immersion of the float varies.

We have seen above that, with a variation of friction of 3 lbs., the variation of immersion $= \cdot 064$ of an inch; therefore, (47 inches being the distance of overflow below the surface of water,) the ratio of maximum velocity to mean $= \sqrt{\frac{47 \cdot 064}{47}} = \frac{1 \cdot 00067}{1}$, which corresponds to an angular deviation in right ascension of 36″ of space per hour.

In practice, however, when the instrument is accurately counterpoised and carefully oiled, the variation of the force required to turn it round in right ascension is probably very much less than this; and if between one night and the next the friction increases through viscosity of the oil, the rate is easily corrected by means of the valve *o*.

This clock has been used for micrometrical observations, and answers perfectly; but how far for spectroscope purposes it will bear comparison with other contrivances has not yet been ascertained.

The accompanying figure has been drawn on a scale of $\frac{1}{3}$ inch to 1 foot, with the exception of the sector *t* and the weight *s*, which keeps the rope *x* extended, these two parts having been drawn on a reduced scale and in a different position to save space.



Depolarizing Iron Ships.

From Newton's London Journal of Arts, May, 1866.

In the March number of this *Journal* we took occasion to notice an invention which Mr. Evan Hopkins, C.E., had brought before the Royal United Service Institution, in the form of a paper entitled "Iron Ships' Compasses: their deviation and remedies," his object being to call the attention of naval men to a means which he had arrived at, by induction, of depolarizing iron ships, and of giving greater vitality and steadiness to compass needles. We then said we should look with interest to the experiments about to be made to test the practical value of the theory of depolarizing iron ships by passing currents of electricity through the hull. The polarity of iron ships is, as is well known, contracted during building, and the character of the polarity

depends principally on the direction given to the ship's head while building; and it is to the action of this attractive power that the deviations in the compass, which perplex and sometimes baffle the skill of the most experienced navigators, are due. We are now enabled to state that Mr. Hopkins has successfully introduced his new system on board an iron ship called the *St. Leonard*, now loading for Adelaide, in the London docks. This iron vessel is 220 feet long and 34 feet wide. When placed in his hands, the stern had a strong south polarity, which caused the steering compass to deviate nearly 40° toward the stern-post, when the head of the vessel was S.E. by E. Even the standard compass, placed in a pillar about 50 feet from the stern, had a deviation of 20° toward the stern-post. The ship had been carefully "swung," and three magnets were fixed as correctors near the steering compass, and a deviation card duly prepared before she sailed on her last voyage to Australia. On leaving the channel, it appears that the captain found both compasses were wrong and could not be depended upon. Under these circumstances, for the safety of the ship, he rigged a compass about 18 feet high in the mast, with a transparent "tell-tale" card, so as to be able to read it from deck, and he navigated the ship by this compass alone, and disregarded the other compasses and the table of deviations.

Mr. Hopkins, when invited to examine the state of the magnetism of this ship, found that she was in a most dangerous condition, and considered that, had not Capt. Franklin detected in time the errors of the compasses and rigged a compass on the mast, above the influence of the masses of iron and magnets below, the consequence might have been very serious. Mr. Hopkins applied his depolarizing apparatus to the top of the stern-post, and in a very short time destroyed its south polarity, giving it at the same time a temporary weak north pole. The moment this was done the deviation of the steering compass was reduced about 18°, and the other compass about 4°. The plates of the vessel have not yet been operated on from stem to stern to destroy the whole polarity of the hull, but when this is done it is expected that nearly all the deviation will be corrected in compasses placed about 6 feet above deck and 12 feet from the rudder-head and the steering-gear. Mr. Hopkins' standard compass was temporarily rigged up the mast, about 15 feet above deck and 35 feet from the steering-wheel, for the experiment. In this position it was found to be beyond the reach of the disturbing influence of the masses of iron in the ship, and therefore would be found always correct in whatever direction the ship might sail. Besides being a *standard* compass, in which every dependence can be placed, it serves also as a steering compass to the man at the wheel.

The temporary experimental compass, although only about 7 inches diameter, can be plainly read from the wheel, like the dial of a clock, by means of a reflector. Its use, therefore, coupled with the corrections of deviation, will dispense with the swinging business, (which is now acknowledged by careful captains to be delusive and often utterly untrustworthy.) Whatever may be the changes in the magnetism of

the ship in high latitudes, the steersman will have the inestimable advantage of seeing from the wheel at all times a correct standard compass, as well as the one placed on deck near the wheel. This steering standard compass is to have a card of 12 inches diameter, with two needles of the strongest directive power in all "dips" between England an Australia.

We believe that, at the suggestion of Sir John Hay, Mr. Hopkins has been requested to prove the efficiency of his plans for removing the cause of the deviation of the compass needle in iron ships by operating on the armor-plated ship the *Northumberland*.

Property of Sulpho-cyanide of Ammonium. By Mr. F. Clowes.

From the London Journal of Science, April, 1866.

A notice of an interesting property of sulpho-cyanide of ammonium has been published by Mr. F. Clowes. He finds that when dissolved in water this salt produces intense cold; in a short time the atmospheric moisture being deposited like hoar-frost on the sides of the vessel.

This led him to try a few experiments with weighed quantities of water and of the salt. From a few trials with different proportions, it appeared that the mixture of equal parts by weight gave the most intense cold. By mixing 1368 grains of the salt with its weight of water at 17° C., a cold of 12° C. was obtained. The temperature of the atmosphere at the time of the experiment was the same as that of the water employed.

On National Standards for Gas Measurement and Gas-meters.

By George Glover, Esq.,

Formerly Lecturer on Natural Philosophy, Royal College of Surgeons, Edinburgh, and Vice-President Royal Scottish Society of Arts and Superintending Medical Inspector General Board of Health, Whitehall.

From the London Journal of the Society of Arts, No. 424.

The subject of gas measurement, which I am about to have the honor of bringing under the notice of the Society, involves the consideration of two kinds of instruments—gasometers and gas-meters. The gasometers are of two kinds—the "national standard gas-holders" deposited at the Exchequer, and those in ordinary use, generally called "testing gas-holders." The gas-meters are also of two kinds—the wet and the dry.

When, more than half a century ago, coal-gas came into use, the want of a measure for its sale was soon felt. Such a measure was perceived to be indispensable in the event of gas becoming a staple article of commerce. To meet this want, Mr. Samuel Clegg invented the instrument which, from its revolving drum or measuring part being partially submerged in water, has been denominated "the wet meter." Ingenious in principle, it was soon found defective in practice. Its principal defect arises from the evaporation of the water, causing constant variation in its measuring capacity. The bottom of the measuring

chambers is defined by the plane of water in the meter, and the measuring chambers are diminished or enlarged by the accidental quantity of water which may be present at any given instant. The water is continually undergoing change of level from evaporation, which is more or less rapid according to the quantity of gas which passes through the meter, and the change of temperature. The wet meter likewise varies in its measurement with every departure from the true horizontal plane. Inclined forwards, it measures too slow; if backwards, it measures too fast. It also varies with the varying pressure of the gas as it enters the meter. To render a wet meter a fixed measure four things are essential:

1. That the plane of the water remain fixed.
2. That the bottom of the meter be parallel with the plane of the water.
3. That the meter be placed and maintained on a horizontal plane.
4. That the pressure of the gas as it enters the meter be uniform.

Compliance with these conditions is impracticable, and it is much to be regretted that the baffled ingenuity and futile devices of half a century have not made this conviction general, and that, at the present hour, there should be large towns, such as Liverpool, Birmingham, Sheffield, and several in Scotland, in which gas companies, to their own injury and that of the public, still adhere to the wet meter, notwithstanding its acknowledged defects.

It has been customary, in cases of doubt as to the accuracy of the measurement of gas by wet meters, to lift them from their place, to put them on a horizontal plane, and to adjust the level of the water to a plane of correct measurement. Such a test is no more a proof of a meter's correct performance than a watch-maker's setting a watch to Greenwich time would be an evidence of the watch having gone correctly for the twelve months past, or a guarantee of its accuracy for the twelve months to come. The only correct method of testing the wet meter's performance during any given time it may have been in use, is to examine the internal surfaces of the back and front plates where the water at its various levels has traced or oxidized distinct lines. In a three-light meter, the distance between the two extremes (viz: the highest and lowest water-line) ought not to exceed $\frac{3}{16}$ths of an inch, so as to give the variation of 5 per cent. allowed by the "Sales of Gas Act;" whereas, in practice, that distance is found to reach an inch, or even more, thus showing, of course, a proportionate amount of variation in the measuring capacity of the meter. The diagrams (Fig. 1) will illustrate this.

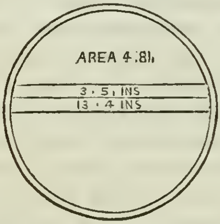
Fig. 1.

Diagrams of wet meters, showing the precise amount of variation.

Two-light Meter.—Scale 1 inch = 1 foot.

Registering 33 per cent. against consumer.
" 7 " " company.

	Square Inches.
Area of segment down to correct water-level, 16·94 + 8·46 =	25·40
" " " highest "	16·94
Against consumer—variation........................	8·46
Then as 25·40 : 8·46 : : 100 : 33·3 per cent.	
Area of segment down to lowest water-level........................	27·22
" " " correct "	25·40
Against company—variation........................	1·82
Then as 25·40 : 1·82 : : 100 : 7·16 per cent.	



Five-light Meter.—Scale 1 inch = 1 foot.

Registering 9 per cent. against consumer.
" 29 " " company.

Area of segment down to correct water-level........................ =	45·31
" " " highest "	41·81
Against consumer—variation........................	3·5
Then as 45·31 : 3 5 : : 100 : 8 96 per cent.	
Area of segment down to lowest water-level........................	58·71
" " " correct "	45·31
	13·4
Then as 45·31 : 13·4 : : 100 : 29·49 per cent.	

There has been no lack of effort to remove this defect in the wet meter. Ingenuity, labor, and vast sums of money have been lavished upon it. The Patent Office, year after year, has been besieged by inventors who imagined they had discovered a remedy; but, for all practical purposes, there has been little, if any, improvement on the original invention.

The inventions which have aimed at preserving a fixed water-line may be reduced to three classes: Those having a reservoir or small cistern in connexion with the meter, and a tube communicating with the surface of the water in the meter, on the principle of a bird fountain; those in which a spoon or bent tube on the axle lifts a small quantity of water in each revolution by dipping into a cistern or water-box; those which float the drum itself, or have a float nicely balanced, of semi-cylindrical or hemispherical form, turning on a horizontal axle mounted near the level of the water in the meter. Many of those inventions have, from time to time, obtained partial success. Some of them have been revived again and again under different names and with slight modifications, but all of them have ended in failure and disappointment. The method of floating the drum Mr. Clegg invented

shortly before his death. The simplicity and theoretical beauty of the invention are apparent, and, could the sides of the revolving drum be kept vertical to the plane of water, the drum itself perfectly balanced and free from deposit; could the water be kept pure, the pressure of the gas free from variation, the moving parts from corrosion, it might be hoped that one serious practical objection to the wet meter had been removed. These conditions, however, all experience has shown cannot be realized.

Vigorous efforts are being made to revive the use of a meter, constructed on the same principle of floatation, which was patented by Messrs. Sanders & Donovan in 1855. Theirs is the simplest and most scientific invention yet propounded for preserving the uniform level in the water-line. Its ingenuity reflects high credit on the inventors. But, without unfairly detracting from this, it may be stated that their invention has increased both the size and complexity of the instrument, that its extreme delicacy and the complication of its parts, while multiplying the chances of error in its workmanship, expose it to quicker decay, and hence repair and replacement are necessarily more frequent. Its delicacy, in fact, unfits it for every-day use, and makes it very liable to derangement. The water in the meter becomes impure and even tarry, impurities, from time to time, are deposited on the float, its balance is impaired, its axle and the float corrode, small holes are formed in it by corrosion, through which the water enters, when it ceases to be a float, so that it not only fails to adjust the level of the water, but becomes more defective than the ordinary wet meter.

It is open, besides, to the very serious objection that, by unscrewing the lower plug, as much gas can be got as from the outlet of the meter itself, a circumstance which offers a strong temptation to fraud.

The variation in measurement is, of course, the grand objection to the wet meter. It is not the only one, however. Though fatal in itself, there are others I may just mention. There is the annoyance from the unsteadiness of the lights, familiarly called "jumping." There is the danger of sudden extinction. There is the danger of escapes of gas through the meter being interfered with, as when the plugs are removed that the water may be replenished, and, through carelessness, not replaced. There is the facility with which the measurement in the same wet meter can be made to vary, either from the quantity of water put into the meter, the inclination given to it, or from both, and the consequent temptation to fraud. There is the necessity of placing it in the basement of the house, and the consequent attempt to prevent the "jumping" of the lights by giving all the pipes a gradual rise from the meter to admit of the water trickling back into it, an attempt at once futile, expensive, and injurious to house property. Its very situation in obscure, out-of-the-way corners is apt to create a suspicion in the mind of the consumer that he is wronged in his measurement, while the gas companies are made dependent on the vigilance of their inspectors to an extent undesirable alike for the employer and the employed. The defects of the wet meter too often

expose the managers and directors of gas companies to unjust suspicions, while really the companies are the greatest losers by it, and the parties most deeply interested in the just measurement of gas. When the meter is found not to have registered at all, or to have registered only a small portion of the gas passed through it, it is not unusual to ask the consumer to pay for his gas without any reference to the meter, but to his payment for the corresponding quarter of the previous year, a mode of adjustment unsatisfactory both to the seller and the buyer.

The interests of the public and the gas companies alike demanded that the evils of a system of measurement, which involved variations reaching sometimes as high as 20 and 30 per cent., should be fairly met. "Why," it was asked, "should not gas be justly measured as other staple commodities are measured? Why should not the consumer have a guarantee that he really gets the quantity he pays for, and the producer that he really gets payment for the quantity he delivers? If security be given for the just measurement of a gallon of oil and a pound of candles, it is not less necessary for a cubic foot of gas." From evidence given before Parliamentary Committees, it appeared that, owing to the want of a legal criterion and inspection, what was called a cubic foot differed, when measured by the meters of one manufacturer as compared with those of another, as much as 3 per cent., and that when the meters were in the most perfect working condition. The prevailing dissatisfaction, and the antagonism, prejudicial alike to the gas companies and the public, to which this state of things gave rise, at length drew the attention of the Legislature to the subject. The result was the bill presented by Lord Redesdale to the House of Lords, in the first session of 1859, for the purpose of establishing a standard cubic foot for gas measurement, and extending the general law of inspection of weights and measures to gas meters, with such other provisions as the special nature of the subject seemed to require.

The "Sales of Gas Act," introduced by his Lordship, received the sanction of the Legislature in the session of 1859. The principal provisions of that Act are sufficiently well known. It fixed, for the first time, as the "only legal standard or unit of measure for the sale of gas by meter, the cubic foot, containing 62·321 pounds avoirdupois weight of distilled or rain-water weighed in air at the temperature of 62° of Fahrenheit's thermometer, the barometer being at 30 inches." And had the Act done no more than this it had conferred an important boon on the gas companies, and on the community at large. A first and important step was then taken in the right direction.

The duty of providing standard measures for gas was devolved by the Act on the Lords Commissioners of Her Majesty's Treasury. The Astronomer Royal's familiarity with the subjects of the standards of weights and measures specially qualified him for such a duty, and his services to the Exchequer in connection with this subject having been acknowledged as of high value, their Lordships applied to him to assist them in providing the requisite instruments. The public and the

gas companies were entitled to expect that the services of a philosopher so distinguished in the application of the exact sciences, should be made available to attain, in the standard measure for gas, as much accuracy as possible.

Acting under the authority of the Lords Commissioners, and aided by Professor Miller, of Cambridge, the Astronomer Royal provided a bottle for measuring the cubic foot defined in section ii. of the Act. In his report to their Lordships of the 11th of February, 1860, he says, "Acting under the authority given by your letters of October 14 and 15, 1859, and having secured the valuable assistance of Professor W. H. Miller, I caused to be prepared a weight of 62·321 lbs., constructed of hard gun-metal, and a metallic vessel or bottle, intended to contain 1 cubic foot, constructed of thin copper, in shape a cylinder with a cone at each end, the upper cone having a small cylindrical neck for the introduction of water, and the lower one having a tap for its discharge." Whether the bottle so described was the best instrument for the purpose may, I think, be fairly questioned. Made of copper it was liable to corrode. The thin sheet of copper was liable to change of form when filled with water, as well as from external injury. Once filled it could not be readily dried. I submit that a geometrical solid, made of anti-corrosive metal, made to exclude, not to contain, the water, and losing in weight the precise quantity of distilled water defined in clause ii., would be free from the objections stated, and could be easily dried after each experiment. It could be preserved, if laid on a soft cushion, under a glass, at the Exchequer, for any length of time, without change or diminution.

Having obtained a bottle fitted to contain the "unit of measure" required by section ii. of the Act, the Astronomer Royal's next step was to apply it in accordance with section iii., which requires that, "within three months next after the passing of the Act, models of gas-holders, measuring the said cubic foot, and such multiples and decimal parts of the said cubic foot as the Lord High Treasurer or the Commissioners of Her Majesty's Treasury shall judge expedient, shall be carefully made, with proper balances, indices, and apparatus for testing the measurement and registration of meters, and such models shall be verified under the direction of the Lord High Treasurer or the said Commissioners, and, when so made and verified, shall be deposited in the office of the Comptroller-General of the Exchequer at Westminster."

In carrying this enactment into effect, it was found that none of the gas-holders hitherto in use for testing meters could be adopted as a standard measure. The more prominent objections to them were these:

1. Their measuring part was not truly cylindrical.
2. No two gas-holders agreed in measurement. Not only did they differ from each other to the extent of 3 or 4 per cent. in their measuring capacity, but the various divisions into feet, and the sub-divisions of the feet, differed in the same gas-holder.
3. The material of which they were made was very liable to corro-

sion when in contact with gas and water. To retard this corrosion paint was used. The paint in the inner surface of the bell diminishes its measuring capacity, and its renewal from time to time aggravates the evil. The coating of paint softens, swells, frequently rises in blisters, falls off in flakes, or crumbles away. In its ascent from the cistern, the painted surface of the bell brings with it a quantity of water, which adheres to it in the form of a film, and numerous drops, which adhere especially to the inner surface of the flat cover. These occasion further diminution of capacity, whilst the evaporation of the water on the outer surface of the bell lowers the temperature, diminishes the volume of the gas contained, and causes error in the testing of meters.

4. The scales of the existing gas-holders were found liable to corrosion, and, not being attached to the bell, they could be readily tampered with. These reasons were sufficient to preclude their adoption as standard measures.

The construction of such instruments as the Act required becoming daily more pressing, and urgent representations being made to the Treasury on the subject, I submitted my designs to the Astronomer Royal, and I had the honor to be employed by the Lords of the Treasury to superintend the construction of the "national standard gas-holders, with proper balances, indices, and apparatus for testing the measurement and registration of meters."

The idea of a legal standard measure, I need scarcely say, involves the highest attainable accuracy. Neither the Legislature nor the public would be satisfied with anything short of this. The subject of weights and measures, even for solids and liquids, for length and capacity, is one of much practical difficulty. The records of the Royal Society abundantly testify how much time, labor, and thought have been given to the solution of these apparently simple questions, "What is a pound weight?" "What is a yard?" Not to travel back into the remote past, I need only remind you of what happened when the Houses of Parliament were destroyed by fire in 1835, and the yard measure perished with them. A Royal Commission was appointed to restore it. After deliberating some twelve years they could find nothing fixed, either in time or space, to which to appeal for a standard measure. Neither the seconds pendulum nor the arc of the meridian of the French philosophers could be appealed to, and they had no alternative but arbitrarily to decide that the rod they had deposited at the Exchequer was a yard. But in constructing a standard measure for gas, the difficulties are much more complicated. The body to be measured is an aëriform body, invisible, highly elastic, varying in volume with every barometric change, very complex in its chemical constitution, affected by every change of temperature, liable to condensation and to be absorbed by water, of which it is also an absorbent.

(To be continued.)

Japanese Matches. By R. Trevor Clarke.

From the London Chemical News, No. 267.

The curious little Japanese fire-work, or one closely allied to it, has been long known to me. I saw it, when a boy, exhibited by an Italian juggler under the name of "garofanetti," or "pinks," alluding to the starry flower-like coruscations produced by it. The sorcerer was, of course, reticent as to the formula, but I set to work and finally succeeded in finding it out. It is a form of the beautiful and very curious spur-fire of the Chinese,—so curious as to be worth scientific investigation.

I enclose specimens, and here follows formula: Lamp-black 5, sulphur 11, gunpowder from 26 to 30 parts, this last proportion variable with the quality of the powder. Grind very fine, and make the material into a paste with alcohol. Form it into dice, with a knife or spatula, about a quarter of an inch square. Let them dry rather gradually, as on a warm mantel-piece, not too near a fire. When dry, fix one of the little squares in a small cleft made at the end of a lavender stalk, or, what is better, the solid, straw-like material of which house-maids' carpet brooms are made, (panicular stems of *Arundo donax.*) Light the material at a candle, hold the stem downwards, and await the result. After the first blazing off a ball of molten lava will form, from which the curious coruscations will soon appear.

For the Journal of the Franklin Institute.

The Working Processes for the Reduction of the Gray Copper (Tetrahedrite) Ores at Stefanshütte, in the Comitat (County) of Zips, in Hungary. By J. L. Kleinschmidt.

The proper working of the gray copper ores is one of the most difficult metallurgical processes. At the Stefanshütte it is now done on a larger scale than any where else in the world. These works, which received a prize medal at the London Exhibition of 1862, were established 16 years ago, and produce, at present, about 300 tons of copper, 3000 lbs. of silver, 60,000 lbs. of quicksilver, and 80,000 lbs. of crude metallic antimony. The works built for the smelting of the gray copper, use of yellow ores only poor quartzose ones, which are necessary for fluxing. The processes, therefore, have a character quite different from that in other places, where the gray copper ores form only a small part of the materials to be melted. One of the main progresses in the last years is the production of metallic antimony from gray copper ores, since more than one-half of the regulus antimonii, which comes in the market from Hungary, is now produced from these ores.

The pure gray copper ores contain, according to the analyses of Von Hauer, (Jahrbuch der Geolog. Reichsanstalt, 1852. Heft 4, page 102:)

	I.	II.	III.	IV.	V.	NAME OF THE MINE.
S	25·90	13·38	24·37	24·89	22·00	I. Bind Appolonia.
Cu.......	36 59	34·23	30·58	32·80	39 04	II. Andraei.
Fe.......	7·11	9·46	1·46	5·85	7·58	III. Gustav Frederici.
Hg	3·07	3·57	16·69	5·57	0·52	IV. Heilg. Geist. Tr.
Sb	26 70	33 33	25·48	30·18	31·56	V. Rothbaum.
As	trace.	trace.	trace.	trace.	trace.	
	99·37	99·97	98·58	99·29	100 50	
Spec. G.	4·605	4·762	5·107	4·733	4·582	

The above ores contain from $\frac{1}{8}$ to 3 ounces of silver in 100 lbs., the average yield of the ores being $\frac{5}{8}$ of an ounce. Besides these, ores are furnished to the smelting works, which contain *no* quicksilver; the ores are therefore separated into two classes—in those containing quicksilver and in those free from it. The veinstone of the mercurial ores consists almost exclusively of carbonate of iron. The other minerals, which are associated and intermixed, sometimes do not amount to 1 per cent. of the sparry iron. The average yield of copper is 10 per cent. Besides gray copper ores, the ores contain about 3 per cent. of yellow copper ores; so that they consist of gray copper ores 2 per cent., yellow copper ores 3 per cent., carbonate of iron 69·3 per cent., other minerals, as heavy spar, slate, quartz, and calcareous spar 0·7 per cent. The ores therefore contain about 7 per cent. of sulphur and 8 per cent. of antimony. The annual production is about 2500 tons of ores, containing about 400,000 lbs. of antimony.

Separation and Collection of the Mercury.—The great volatility of this metal requires that it should be separated first. The process is a very simple one, but nowhere else in use, and consists in the roasting of the ores in large round furnaces, and collecting the quicksilver in the upper layer of the ore. On the bottom of the furnace is placed a layer of fine ore of 4 inches in thickness, then follows a layer of wood of 22 inches, and on this 6 inches of charcoal. Now follow layers of partly roasted ore, but not yet free of quicksilver. The fine ore is added in stripes radiating from the centre, whilst between these the lumps are placed, otherwise the furnace would have no draft. Therefore the ores, which have been once roasted, but yet contain mercury, are separated by sieves into fine ore and lumps. Uppermost come the fresh unroasted ores, and the top layer, in which the quicksilver is condensed, consists in lumps only of different sizes, (Stufen & Graupen.) The whole quantity amounts to 50 tons, and forms a layer about 2 feet high. A wood-pile is in the centre of the kiln, from which it is fired and burns during about four weeks. In consequence of the heat produced by the burning of the ores, the mercury is volatilized, and passes through the upper layers of the ore, where it is condensed in the form of globules. It is only necessary that these remain throughout and at all times cold, and that the places which perhaps get warm

are at once covered with cold lumps to prevent the loss of mercury; therefore watchmen are at the furnaces, day and night, during the whole process of operation.

After the kiln is burnt out, the upper layer, which is full of metallic quicksilver, is cautiously taken away, and washed in wooden tanks by the help of sieves, as it is done in the washing of ores. The quicksilver goes through the sieve, and remains with the ore dust on the bottom of the tank. From the latter it is separated by boys, who wash it in small wooden troughs. For this purpose in a building are three tubs containing water, and on each of them stand three or four boys, ten to sixteen years old. Every one takes some of the mixture of dust and quicksilver in his trough, (sichertrog,) and, keeping it below water edge, he gives it a great many small shocks against the wall of the tub, whereby the quicksilver settles to the bottom of the trough. The water of the tub is mixed with some quicklime, otherwise the quicksilver would contain copper. That part of the roasted ore which yet contains quicksilver is worked over a second time, as described above; the lower portion, however, which is free of mercury, goes to the furnace. The quicksilver obtained is not pure; it contains silver and copper, and must be distilled in an iron retort. The distillation must be conducted very slowly, otherwise traces of copper are also volatilized. If carefully done the distilled mercury contains no foreign substances, except some sub-oxide of mercury. Formerly, when the distillation was done too rapidly, the quicksilver sometimes contained traces of copper. The residuum in the retort consist in ore dust and metallic silver, the latter containing copper and gold.

After the roasting, almost the entire lower part is melted together, and most of the sulphur has combined with the iron of the sparry iron. The volatile products formed by the roasting have a strong smell of sulphurous acid and bisulphuret of carbon. Besides the smoke of wood, there are generally no other vapors emanating from the roasting kiln. Sometimes arsenious vapors can be perceived. In this roasting process there are never observed the dense vapors, which arise by the roasting of the matte, (lech,) but the atmosphere contains only an invisible gas, which acts seriously on the eyes and lungs.

The yield of the ore by this process is 94 per cent. of the mercury, found by assay. In former times a great many and costly experiments were made to distill the quicksilver in retorts, furnaces, and every possible apparatus, and to condense it then in chambers and pipes placed in cold water; but the above simple method, by which fresh cold ore is employed for the condensation of the quicksilver, has superseded all others.

In relation to the chemical process, the protoxide of iron of the sparry iron may have a prominent part in driving out the mercury, because the melted mass on the bottom of the furnace consists partly of sulphuretted metals and partly of antimonial metals, (speiss.) Most of gray copper ores give out metallic mercury by heating them in a sealed glass pipe; in others, here and there red cinnabar can be seen. The latter yield the mercury only by heating them in an open pipe,

so that we have three causes here, by which the quicksilver is set free: 1. The heat alone; 2. The oxygen of the air; and 3. The influence of the oxide of iron. The average yield of the ores amounts to 1·63 per cent. of mercury.

Matte Smelting, (Rohschmelzen.)—After the separation of the mercury the ore is smelted. The mixture consists of roasted ores with about 40 per cent. of the crude gray copper ores, free of mercury, and to 100 of this mixture are added 6 parts of iron pyrites of Schmöllnitz, 20 parts of poor quartzose ores, and 20 parts of slag of the melting of the roasted matte, (lech.)

Qualities and Composition of the Materials.—It was above mentioned that the lower part of the roasted heap, which is free of quicksilver, consists of sulphurets and antimoniurets of metals. Above it is a layer, also free of quicksilver, consisting chiefly of peroxide of iron, and very little protoxide. The carbonate of iron is in this layer very rare, as it has mostly been changed into peroxide.

The composition of the raw ores can be stated as follows: Gray copper ores 26 per cent., yellow copper ores 4 per cent., sparry iron 64 per cent., slate and quartz 4 per cent., and arsenical iron 2 per cent., and about 2 ounces of silver in 100 lbs., which is more than the average yield of the mercurial gray copper ores.

Pyrites of Schmöllnitz.—These are bought from several companies, which work, besides the Austrian government, on the well-known deposits of pyrites called the Kiesstock. These pyrites ores give, by the crucible assay, 70 per cent. of matte, (lech,) contain $\frac{1}{8}$ of an ounce of silver in 100 lbs., and less than $\frac{1}{2}$ per cent. of copper, $\frac{1}{2}$ to 4 per cent. of lead, and small quantities of zinc, antimony, and arsenic.

Quartzy Flux Ores.—These are yellow copper pyrites ores dispersed in quartz. The average yield of these ores is from 3 to 6 lbs. of copper in 100 lbs. They contain only small quantities of iron pyrites, arsenical iron, sparry iron and gray copper ores. These ores are received at the melting works about one-third in lumps of about an inch in diameter, and two-thirds as ore dust, (scheidklein.)

The furnaces employed for the melting are so-called half-high furnaces, of the following dimensions in Austrian measure: From bottom stone to the mouth $24\frac{1}{2}$ feet, from bottom stone to the tuyeres 6 feet, from the tuyeres to the cinder hole, downwards, measured 29 inches, height of the boshes $1\frac{1}{2}$ feet, inclination of the boshes 45°, width of the bottom of the hearth $3\frac{1}{2}$ feet, width of the boshes 5 feet, of the mouth 18 inches. The furnaces are circular, and the 2 tuyeres blow in the centre of it. They have a diameter of $1\frac{1}{4}$ inch on the mouth. The pressure of the air is seven-twelfths to ten-twelfths inch quicksilver. The rough mason-work of the furnaces is of slate—the interior shaft of fire-proof talcose slate. They stand on a foundation 15 feet high, which lays on solid rock. The melting is done by a half-lighted nose, and one furnace melts in 24 hours 5 tons of ore.

The cinders or slags are tapped every 15 minutes, and the tapping hole is stopped with loam. There are prepared several small but deep crucibles (tiegel) in front of the furnace, united by a kennel. The

last consists in a flat hollow of 7 to 8 feet in diameter, which is called *sump*, (sumpf.) In the first of the crucibles, whilst the melted metals take their way through them, the "speiss" is deposited, covered by a layer of matte, (lech,) but the most of the latter goes to the sump, in which it hardens to a layer of one to two inches in thickness, and while yet warm is broken to pieces. As soon as the tapped metals are cold, the smelter takes away the solid matte by a fork, (forkel,) and when he comes to the speiss he puts in it a piece of iron, which has a ring above, by the means of which he takes it out after cooling.

I have found the composition of the products of the matte melting (rohschmelzen) to be—

Matte, (produced Feb., 1864.)	
Cu	22·10
S	25·80
Fe	47·62
Sb	3·37
Ag	0·08
Slag	1·40
	100 37

Speiss, (produced June, 1864.)	
Cu	26·93
Sb	62·41
Fe	8·91
Co. & Ni	0·20
S	1·37
Ag	0·20
	100·02

Slag, (rohschlacke,) (produced Feb., 1864.)	
SiO_3	46·60
S	2·24
Sb	0·80
Cu	0·40
FeO	42·21
CaO	3·78
MnO	2·60
Al_2O_3	0·80
	99·43

Conditions for the Formation of the Speiss.—The formation of the speiss was known to me already in 1847, when I became acquainted with it at the imperial Altwasserhütte, where, at that time, the same gray copper ores were worked up, which are now used at the Stefanshütte. In 1853 I was engaged on the melting works of Wissenbach, near Dillenburg, in the Duchy of Nassau, Germany, in finding a method for the profitable working of the gray copper ores of that district. The veinstone of these ores, renowned for the beauty of the crystals and the scarcity of their occurrence, consists of quartz. I added slag from puddling furnaces, slag from the melting of roasted copper matte, and some lime, but no speiss was obtained. I soon found that the production of speiss depended upon the presence of metallic iron in the melting process. I obtained speiss without difficulty by the direct addition of wash iron, (from the stamping of slag of an iron furnace,) as also by that of roasted sparry iron. The matte melting (rohschmelzen) of the Stefanshütte does, therefore, not produce any secretions of metallic iron, (eisensauen, salamander,) as it is the case at the Phönixhütte and other melting establishments, belonging to the same association, and where the yellow copper ores are melted, because, instead of the iron, and by the aid of it, the easily fusible antimony is separated.

So long as it was not possible to extract the silver from the speiss by amalgamation, its appearance was not liked. The desideratum was to make as small a quantity as possible, and several times experiments were made to avoid its production altogether. Only recently a method was discovered to separate, by amalgamation, the silver from the speiss with the same facility and quite as perfectly, as from the black coppers. Besides this, a method was found to reduce the yield of copper in the speiss to such an extent that the copper in the crude antimony is more than paid, so that it is now perfectly reasonable to reduce more and more the addition of the pyrites, which prevented the formation of too large a quantity of speiss, and to produce more speiss, and to work it up by itself. Not taking into consideration the considerable quantity of antimony, which thereby is gained, the main profit is in the diminution of the by-products; further on we will see that the working up of these forms a great part of the operations of the Stefanshütte, and that it is certainly easier to separate the antimony at once than to volatilize it by an endless series of processes. The second reason is that thereby a much better copper can be produced. It will be seen from the analyses below, that cobalt and nickel go chiefly into the speiss. These elements, in combination with the antimony, impart bad qualities to the copper, but it is much more convenient, therefore, to separate them from the copper by precipitating them in combination with the antimony, than by driving them into the slags in the refining process of the copper.

The speiss of this melting has a gray color, almost that of steel, the fracture is fine-grained, sometimes with traces of crystallization. It is very brittle, and can easily be converted to the finest powder; red-hot in contact with the air it gives white fumes. The specific gravity differs but little from that of the matte, therefore and because the mass runs with great rapidity through the crucibles, the speiss has no time to separate perfectly. The same contains, therefore, some matte mixed with it, which is visible in small particles. From it comes the sulphur, which is shown by the analysis. On the other hand, the matte contains visible particles of speiss. From the above analysis it will be seen, and the results on a large scale prove it, that the speiss contains three times as much silver as the matte, produced at the same time. Formerly, before it was understood, how to amalgamate the speiss, the loss of silver was very great; now, the antimony has proved itself a conservator of the silver, the latter not being more subjected to the losses, which are inevitable by the roasting of the matte, for the purpose of melting them to black copper. Besides that, the silver is gained three months sooner than when obtained from the black copper.

First or Crude Matte, (*Rohlech.*)—Bredberg determined the amount of sulphur in the matte (rohlechs) to 26 per cent., which accords with the above. (The same is the case with the matte of the Phönixhütte.) Results quite different from these are given by Le Play in his examinations of the Swansea melting processes. The amount of copper, too, is far less than in the matte of the English melting works. In Hun-

gary they fear to lose copper, if the first matte contains more than 25 per cent. of this metal. The matte of the Stefanshütte forms a mass, with a great many blisters, of steel-gray to violet color; because it gets solid in the sump. In a pretty thin layer it is easily broken to pieces. I made a great many trials to ascertain the amount of antimony in the matte. By the roasting of these mattes an immense quantity of white smoke emanates from the heaps, which is so dense that it is impossible to see through it. In the night this smoke is seen from a distance of some miles as a fiery cloud. By seeing this great quantity of smoke, and considering that the produced black copper contains yet 8 to 13 per cent. of antimony, the quantity of 3·58 per cent. of antimony seems too small; but notwithstanding there are not less than 126,000 lbs. of antimony in the 3,500,000 lbs. of matte, produced during a year. Of these are found 34,000 lbs. in the black copper, (400,000 lbs. with 8·5 per cent. Sb,) so that 92,000 lbs. of antimony pass into the air by the roasting of the matte and the melting for black copper. The 400,000 lbs. of antimony contained in the ores, which are smelted during a year, are distributed as follows:

	Pounds.		Pounds.
Lost by the first melting	60,000	Annual production of—	
Contained in the crude speiss	190,000	Speiss	300,000
" " " slag	24,000	Slag	3,000,000
" " " matte	126,000	Matte	3,500,000
	400,000		

Crude Slag (*slag*) *from the Melting for Matte*, (*Rohschlacke.*)—The crude slag of the Stefanshütte was in former times of a pale, stony aspect, contained visible quartz pieces and interspersed grains of matte. It was very imperfectly decomposed by chlorhydric acid. Since the addition of the pyrites was diminished, the visible quartz pieces have mostly disappeared, the color of the slag became darker, and interspersed grains of matte are very rarely visible. The amount of SiO_3 in well melted pieces is fallen from 50 per cent. to 46·60 per cent.; yet this is more than that of the crude slag of the Phönixhütte, where the majority of the ores are quartzose.

This result is astonishing. The ores of the Stefanshütte contain only oxides as veinstone, and the quartzy ores are only added to remove these oxides in the form of slags. Now, where the acidity of the slags is known, the tendency is to diminish the quartzy additions, otherwise the diminution of the pyrites from 14 per cent. to 6 per cent. has rendered the slags more fusible, because a larger quantity of sparry iron can thereby be turned into slags. The same process could be observed here as by the formation of the Skumnas at Atvidaberg, in Sweden; in both cases, by the great amount of sulphur in the mixture, the slag was deprived of iron.

The melters, therefore, add much more kupferrostschlacke, (slag, obtained by melting roasted matte for the argentiferous black copper,) if they can get it, than the above-mentioned 20 per cent. They further add limestone to increase the fusibility of the slag, wherefrom the

presence of lime, shown by the analysis. The slag of the Stefanshütte could previously never be used for making slag bricks, which were needed in great quantities for building purposes and paving, and were brought from the Phönixhütte; but now, since slags are produced containing less silica, and are therefore more easily fusible, and less stony, they can be used for slag bricks. The small amount of antimony in the crude slag is very remarkable, whilst it rises in the slag of the refining process to 20 per cent. By the crude melting a great portion of the antimony is volatilized, partly from the mouth, partly from the so-called "lichtloch," (lighthole,) an aperture of about one inch diameter opposite the tuyeres, from where it bursts out with white flame, which at night is employed for lighting the works. According to my calculations, by the first melting about 60,000 lbs. of antimony escape to the atmosphere.

Methods of Analysis.—The analysis of all these antimonial products has great difficulties, because the decomposition by chlorine or the melting with sulphide of potassium were not practicable for most of these products, containing small quantities of antimony, and which are often difficult to reduce to powder. I adhered to the method of dissolving them in fuming nitric acid; but hereby very often basic salts are formed, which cannot be decomposed by nitric acid, and which, when once dry, are insoluble in hydrochloric acid. Reischauer, in Munich, analyzed such a substance remaining from the solution of copper, used by the coppersmiths of Munich, but does not mention the melting works, where the copper was produced. (Die Parasiten des Werk-kupfers, Oestr. Zeitschrift, f. Berg. and Hüttenw., 7 Nov., 1864.) He found in it, after being dried over oil of vitriol,—

SbO_5	66·61
PbO	10·91
CuO	7·97
SbO	2·28
NiO	2·17
FeO	1·66
HO	8·22
	99·82

I have not always obtained basic salts; from crude speiss and speiss resulting from the melting of refining slag always, but never from crude metallic antimony free of iron, (see below.) In general it seems they are formed when the solution goes on slowly, and if the substance, to be dissolved, is in excess of the solvent. This residue, after slight glowing, I calculated as SbO_4, but I always examined it before the blow-pipe, and then made the necessary deductions. For that purpose I weighed a part of it, mixed it with cyanide of potassium, soda, and some borax-glass, and melted it, enveloped in a cylinder of soda-paper, before the blow-pipe, whereby iron, cobalt, and nickel could easily be recognised. It is possible, when cobalt and nickel are present in small quantities only, to estimate their quantity according to the intensity the borax beads obtained. The copper remains as a

pure grain, and can be weighed exactly. Here the figures obtained by the analysis of the crude speiss, (rohspeise.)

One gramme reduced to fine powder was dissolved in pure fuming nitric acid. The solution was diluted, and after the residue was perfectly settled, filtered, and then washed, ignited, and weighed = 0·790 gramme = 63·667 per cent. of antimony. 0·0200 gramme of this residue gave 0·0025 grammes of copper = 0·987 per cent. This deducted from above remain 62·68 per cent. of antimony; of iron only a trace was present; of nickel a trace; cobalt could not be found in it, but in several samples of the speiss its presence was indicated to the extent of about 0·2 per cent., by borax beads before the blow-pipe.

(To be continued.)

On Scientific Experiments in Balloons. By JAMES GLAISHER, F.R.S.

Proceedings of the Royal Institution of Great Britain, No. 41.

(Concluded from page 51.)

The speaker stated that, at the end of the year 1863, the results for temperature were laid down on a diagram, and the resulting curve was a hyperbola. Continuing this curve upwards, and reading out the decrease of elevation, the following were the results: That at the height of

50,000 feet	the decline of temperature from the earth			would be	83	degrees.
100,000 "	or 19 miles	"	"	"	97	"
200,000 "	38 "	"	"	"	106	"
538,000 "	100 "	"	"	"	112¾	"
1,056,000 "	200 "	"	"	"	115½	"

Showing that large changes take place near the earth, amounting to 24° in the first mile, becoming less and less the further removed, till the change from 100 miles to 200 miles is less than 3°.

The speaker then said, as these results were deduced chiefly from experiments in the summer and during the hours of the day, it became desirable to take experiments at other times in the year, to ascertain whether this law would hold at all times of the year and at all times of the day.

For this purpose it was necessary to take experiments in the winter, spring, and autumn. He then described the experiments made at these seasons, and pointed out that experiments made on September 29, January 12, and April 6, during the day, differed very much from the general laws, and those on June 13, 20, and 27, made a little before, at the time of sunset, and a little afterwards, differed materially from those made when the sun was at a good altitude; for instance, on June 13, at the time of sunset, no difference in temperature was experienced for 2000 feet from the earth.

The speaker then said, it is very clear from the particulars of each ascent, that they cannot all be combined or all used in deducing general laws. Those ascents which have been made during the past year under similar circumstances to those from which the laws of decrease of tem-

perature were found, when combined, do not change the values previously found to any great amount; but those which have been made under other circumstances, such as in the winter, and at times of the setting sun, differ very greatly indeed.

The deviation from this law, however, in winter is certainly of the highest importance to us, the meeting of a strong current of air from the south-west of so great a depth as nearly one mile, over our country on January 12, in the season of winter, which current I know continued many days, must have exercised great influence. This was the first instance of meeting with a stream of air of higher temperature than on the earth; above this the air was dry, and higher still it was very dry: fine granular snow was falling thickly above this warm stream of air.

The south-west current being thus observed is of the highest importance as bearing upon the very high mean temperature we experience during winter, so much higher than is due to our position on the earth's surface, and it is highly probable that to its fluctuations the variations of our winters are due.

Our high winter temperature has hitherto been referred for the most part to the influence of the heated water of the Gulf Stream, but if this were the case, the same agency being at work around the coast of France should exercise the same influence, yet we know that the winters of France are more severe than our own, though situated so much south of us.

Dr. Stark of Edinburgh, some years since, referred the mildness of the winters in Britain for the most part to prevalence of the south-west or anti-trade wind, which is the prevailing aërial current in this latitude during winter.

He observes, so long as these winds blow, we have no frosts or intense colds; but the moment the wind changes during winter to an easterly, north-easterly, or northerly direction, we have both frost and snow, and more or less intense cold.

The south-west winds, in their course, meet with no obstruction in coming to us, but they blow directly to us and to Norway over the Atlantic; and hence we enjoy a much milder climate during winter than any other lands not similarly situated with regard to such winds.

The south-west winds cannot reach France until they have crossed the whole of Spain and the high mountain range of the Pyrenees; and by the time they have crossed that mountainous country they are so much cooled that France can derive comparatively little benefit from them, and hence, apparently, her more severe winters.

Another fact may be inferred from this winter trip; it has always been a matter of great difficulty to me to account for the simultaneous appearance of dense fog over the whole country and extending far out to sea, but the fact of a warm current of air, situated under a mass of snow falling, would fully account for the production of any amount of fog.

Another inference may be drawn from the facts noticed. One only I will mention, and it is this: If during the prevalence of a warm

current of air passing over these islands there can be currents of air of so low a temperature as I experienced, it is evident that, as it is but a struggle between two or more forces, either of which may preponderate at any moment, it is not safe, therefore, in the winter months, how mild soever the weather may be, to go thinly clothed at any time, for at any moment this warm current may be deflected, and its place occupied by the old current, and thus some of our sudden and apparently unaccountable changes may be due.

The fact of no change of temperature being met with at the time of sunset on June 13, for 2000 feet from the earth, that a much smaller change took place than usual on June 20, a little before sunset; and that on June 27, after sunset, as well as could be determined, the change to 3000 feet was small, it would seem that the *laws which hold good by day do not hold good by night. Indeed, it seems probable that at night, for some little distance, the temperature may increase with elevation instead of decreasing.* This can only be determined by experiments at night.

Comparing the results of one experiment with another, with respect to the moisture in the air, at the same elevation, it is found to be very different at different times, and that, on the same day, the moisture is very differently distributed, there having been on some of the days of experiments several successive wet and dry strata placed one above the other.

The variation in this climate, its frequent disturbed atmosphere, the smallness of the country, causing great anxiety after passing through clouds and out of sight of the earth, for fear of descending over the sea, when the balloon has no longer power to keep up, rendering each experiment so limited in its duration, that perhaps this country is not the best for determining the laws which govern atmospheric changes.

I am glad to learn that similar observations are contemplated being made in France, and I hope that similar observations will be made in other countries, for it is probable that above the large plains of the continent, where the weather is more uniform, and where an observer can be for hours out of sight of land without anxiety—that the experiments can be more easily made, and probably, too, the general laws made more easily apparent.

Many ascents will, however, be necessary; clouds as large, and clouds far colder than any I have met with, were experienced by Messrs. Bixio and Barral, in their ascents in June and July, 1850, from Paris. These gentlemen made two ascents for scientific purposes, and although from accidents the ascents were of short duration, the results were of high interest. Among them, they noticed that they passed through a cloud of icicles, which sustained themselves in the air, as it appeared to them, contrary to the laws of gravity; but upon their horizontal surfaces they saw beneath them, however, an exact image of the sun, formed by the reflexion of the luminous ray on the crystals of ice floating about in a foggy atmosphere; and they noticed the temperature of the cloud to be as low as minus 40°, a far greater degree of cold than I ever experienced.

With such variations as these, as many ascents will be necessary to be made in France as in England, to determine general laws; but each ascent may be made far richer in results than any one in England. In France, the duration of a journey will be limited only by the wishes of the observer and not as here by the sea, or by one solitary hour's observations—that being the time frequently in which we approach the sea.

It is certain that there are, in the higher regions of the earth's atmosphere, spaces subjected to great cold, and others to considerable heat; that there exist some clouds of very low temperature; and some, as those passed through on January 12, for a mile in thickness, of comparatively high temperature.

The presence of such, either cold or hot, currents passing over the country, must play an important part in all our meteorological phenomena, and must exert a great influence upon our climate.

When I first undertook to make these experiments, I expected that a few ascents would have given the information sought. The number of experiments I have now made is twenty-five, and so far from exhausting the subject, they have only indicated a much wider field for future operations.

The law of decrease of temperature under ordinary circumstances, both with a clear and a cloudy sky, when the sun is above the horizon, in the months of summer, I think, is pretty well determined; but from the series of observations made in winter, we cannot say such laws hold good throughout the year: neither can we say that the laws which hold good by day will be true by night; and the general result of these differences must be that the theoretical law of refraction now used must be abandoned, and that every observatory will have to determine its own laws independently.

Solar Radiation.—Blackened Bulb Thermometer and Herschel's Actinometer Observations.—On August 21, at the heights of 7000 and 8000 feet, the blackened bulb thermometer, exposed to the full influence of the sun, read 3° only higher than the shaded thermometer.

On September 29, at the height of 14,000 feet, the excess of reading of the blackened bulb thermometer was 2½° only under a bright sun, the increase of readings of the actinometer was from 3 to 5 divisions only; at 13,000 feet, the excess of the blackened bulb readings increased to 4° and 5°, and the increase in one minute of the actinometer reading were 7 to 8 divisions. At the height of 3000 feet and 4000 feet, the influence of the sun increased, raising the blackened bulb to 7° and 8° in excess of the readings of the shaded thermometer, the scale readings of the actinometer increased to 20 and 25 divisions in one minute, and on reaching the ground the increase in the same time were from 45 to 50 divisions.

On January 12, the readings of the exposed and shaded thermometers were nearly alike.

On April 6, I was unable to use the actinometer, and never succeeded in placing it properly. The excess of reading of the blackened bulb thermometer was but small during the cloudy state of the sky

and increased to 5° and 6° at 10,000 feet; this excess increased on descending into the lower atmosphere, until cloud was entered.

On June 13, the excess was at all times small.

On June 20, at many inspections, the readings of the two thermometers were identical.

On June 27, the exposed thermometers nearly always read lower than the shaded thermometer; on examination of these instruments afterwards, they were both found to read correctly.

On August 29, the blackened bulb thermometer read lower than the shaded thermometer till 6000 feet were passed; it then read higher, increasing to 7° at 14,000 feet high.

From all these experiments it seems that the heat rays in their passage from the sun pass the small bulb of a thermometer, communicating very little or no heat to it, similar results being shown by the use of Herschel's actinometer on every occasion that I have had an opportunity of using it. *From these experiments we may infer that the heat rays from the sun pass through space without loss, and become effective in proportion to the density of the atmosphere or the amount of water present through which they pass, and if so, the proportion of heat received at Mercury, Venus, Jupiter, and Saturn may be the same as that received at the earth, if the constituents of their atmospheres be the same as that of the earth, and greater if the density be greater, so that the effective solar heat at Jupiter and Saturn may be greater than at either the inferior planets, Mercury or Venus, notwithstanding their far greater distances from the sun.*

Different Velocities of Air.—The Wind.—On September 29, the balloon left Wolverhampton at 7 h. 43 m., A. M., and fell near Sleaford, a place ninety-five miles from the place of ascent, at 10 h. 30 m., A. M. During this time the horizontal movement of air was thirty-three miles, as registered at Wrottesley Observatory.

On October 9, the balloon left the Crystal Palace at 4 h. 49 m., P. M., and descended at Pirton Grange, a place thirty-five miles from the place of ascent, at 6 h. 30 m., P. M. Robinson's anemometer, during this time, registered eight miles at the Royal Observatory, Greenwich, as the horizontal movement of the air.

On January 12, the balloon left the Royal Arsenal, Woolwich, at 2 h. 8 m., P. M., and descended at Lakenheath, a place seventy miles from the place of ascent, at 4 h. 10 m., P.M., at the Royal Observatory; by Robinson's anemometer, during this time, the motion of the air was six miles only.

On April 6, the balloon left the Royal Arsenal, Woolwich, at 4 h. 8 m., P. M. Its correct path is not known, as it entered several different currents of air, the earth being invisible owing to the mist. It descended at Seven Oaks, in Kent, at 5 h. 37 m., P. M., a point fifteen miles from the place of ascent; five miles was registered during this time by Robinson's anemometer at the Royal Observatory, Greenwich.

From all the experiments, *the velocity of the air at the earth's surface appears to be very much less than at a high elevation.*

Different Currents in the Atmosphere.—The Wind.

1862.—July 30.

The direction of the wind before starting was N. W.

At 4h. 41m. 15s., at	480 feet, the direction of the wind was				S.W.
" 5h. 17m. 30s., "	5165	"	"	"	N.N.W.
" 5h. 40m. 30s., "	6183	"	"	"	N.

1862.—September 1.

The direction of the wind before starting was E.N.E. verging to E.

At 5h. 4m. 0s.,	P. M., at	3268 feet, the direction of the wind				E.N.E.
" 5h. 10m. 0s.,	"	3318	"	"	"	E.
" 5h. 11m. 30s.,	"	3560	"	"	"	E.S.E.
" 5h. 17m. 0s.,	"	3580	"	"	"	E.N.E.
" 5h. 36m. 0s.,	"	4190	"	"	"	W.

1863.—March 31.

At 4h. 58m. 0s.,	P. M., at	18,302 feet, the direction of the wind was				N.E.
" 4h. 58m. 30s.,	"	17,097	"	"	"	S.W.
" 5h. 12m. 0s.,	"	20,865	"	"	"	nearly W.
" 6h. 15m. 0s.,	"	4,441	"	"	"	S.E.
" 6h. 16m. 0s.,	"	5,168 moving back again.				

1863.—July 11.

Before starting the wind was E.

At 4h. 59m. 30s., at	2633 feet, the direction of the wind			N.
" 7h. 14m. 0s., "	1876	"	"	E.
" 7h. 56m. 45s., "	1020	"	"	S.E.
" 7h. 57m. 0s., "	1000	"	"	W.

1864.—January 12.

At 2h. 9m. 0s., at	655 feet, direction of the wind was			N.E.
" 2h. 14m. 0s., "	1,328	"	"	E.
" 2h. 11m. 0s., "	1,518	"	"	S.W.
" 2h. 32m. 0s., "	5,401	"	"	S.
" 3h. 3m. 0s., "	8,086	"	"	S.S.W.
" 3h. 20m. 0s., "	10,017	"	"	S.S.E.

Comparison of the Temperature of the Dew-point by different Instruments.—In the experiments of every year, there seems to be no certain difference in the determination of the temperature of the dew-point by Daniell's and Regnault's hygrometers, and this temperature, determined by the use of the dry and wet bulb thermometers, seems to be very closely approximate indeed to the results obtained by either of these instruments, as will be seen by the following comparison of results.

As found from all the simultaneous determinations of the temperature of the dew-point by Daniell's hygrometer, and the dry and wet bulb thermometers (free), the temperature of the dew-point by the dry and wet bulb (free) up

	Feet.		Feet.		Deg.			Experiments.
		to	1,000	was	0·1 lower than by Daniell's hygrometer from			21
From	1,000	"	2,000	"	0·1	"	"	40
"	2,000	"	3,000	"	the same as by	"	"	54
"	3,000	"	4,000	"	"	"	"	60
"	4,000	"	5,000	"	0·4 lower than by	"	"	33
"	5,000	"	6,000	"	0 6 "	"	"	33
"	6,000	"	7,000	"	0·2 "	"	"	34
"	7,000	"	8,000	"	the same as by	"	"	8
"	8,000	"	9,000	"	1·5 higher than by	"	"	2
"	9,000	"	10,000	"	1·2 "	"	"	2
"	10,000	"	11,000	"	0·3 "	"	"	1

From 11,000 to 12,000	was 5·6	lower than by Daniell's hygrometer	from 3
" 12,000 " 13,000	" 0·3	higher than by "	" 5
" 13,000 " 14,000	" 0·8	lower than by "	" 7
" 14,000 " 15,000	" 1·0	" "	" 2

The number of experiments made up to the height of 7000 feet, varying from 21 to 60 in each 1000 feet, as taken in the last three years, are sufficient to enable us to speak with confidence; the results are, that the temperatures of the dew-point, as found by the use of the dry and wet bulb thermometers, and my hygrometrical tables, are worthy of full confidence up to this point. At heights exceeding 7000 feet, the three years' experiences do not yield a sufficient number of experiments to give satisfactory results. Before we can speak with certainty at these elevations more experiments must be made.

Let us take the balloon as we find it, and apply it to the uses of vertical ascent; let us make it subservient to the purposes of war, an instrument of legitimate strategy, or employ it to ascend to the verge of our lower atmosphere; and, as it is, the balloon will claim its place among the most important of human inventions, even if it remain an isolated power, and should never become engrafted as the ruling principle of the mechanism we have yet to seek.

Whether we regard the atmosphere as the great laboratory of changes which contain the germ of future discoveries, as they unfold to the chemist, the meteorologist, the physician; its physical relation to animal life at different heights; the form of death, which at certain elevations is certain to take place; the effect of diminished pressure upon individuals similarly placed; the comparison of mountain ascents with the experiences of aëronauts; these are some of the inquiries which suggest themselves, and faintly indicate researches which naturally ally themselves to the course of balloon experiments.

Sufficiently varied and important they will be seen to rank the balloon as a valuable aid to the uses of philosophy, and rescue it from the impending degradation as a toy, fit only to be exhibited or to administer to the pleasures of the curious.

Already it has done for us that which no other power has accomplished; it has gratified the desire natural to man, to view the earth in a new aspect, and to sustain himself in a new element, hitherto the exclusive privilege of birds and insects. We have been enabled by its aid to ascend among the phenomena of the heavens, and to exchange conjecture for instrumental facts, recorded at twice the elevation the highest mountain permits us to observe.

A New Star.

Dr. B. A. Gould, Jr., of Boston, publishes in the *Boston Transcript* an account of the discovery of a new variable star in the constellation of the Northern Crown. The star, when first seen, on the night of the 14th of May, was brighter than any other, except one, of that constellation, which would put it between the second and third magnitudes.

It now appears that it was observed on the night of the 12th of May, by a pupil of the Friend's High School, in this city, and on the same night by Prof. Tutweiler of Havana, Green Co., Alabama, who reports it as "about or above the second magnitude, and a little brighter than Alphecca or Gemma, (α Coronæ.) It rapidly decreased, on the 19th was barely visible to the naked eye, and on the 20th was visible only through a small telescope, and it continued to decrease at an almost uniform rate until the 24th of May. The Paris journals notify us that the same star was detected by M. Courbebaisse, at Rochefort, on the night of the 13th of May. Its position and brightness accord with the observations here.

The close accordance of the times of detection of this star will show how closely the heavens are now watched, and how familiar even amateurs are with the principal stars of the heavens.

Since the above was written we learn from the Monthly Notices of the Royal Astronomical Society, (England,) that this same star was noticed on the night of the 12th by Mr. Birmingham, of Tuam, who has, therefore, decided priority of discovery. But a more important fact is that Mr. B. immediately reported his discovery to Mr. Higgins who has recently given us, by means of the spectroscope, such valuable information in reference to the physical constitution of the stars. His results are so interesting that we give his report in full.

"On May 16 I received a note from Mr. John Birmingham, of Tuam, in which he informs me that, on the night of May 12, he saw a new star near ϵ *Coronæ* B. He describes the star as 'very brilliant, of about the second magnitude.' The same day a letter arrived from Mr. Baxendell; he observed the star on the 15th, and found it to be fully equal in brightness to β *Serpentis* or γ *Herculis*.

"On the night of the 16th, I and Dr. W. A. Miller examined the spectrum of this strange star. The results of our observation were communicated on the 17th to the Royal Society.

"On the 16th, the star was brighter than ϵ *Coronæ* B, fully ·5 magnitude, perhaps ·75 magnitude brighter than ϵ. On that evening a very faint nebulosity was seen extending some little distance round the star, and gradually fading away at its outer boundary. A comparative examination of neighboring stars showed that this appearance of nebulosity was due to the star itself. On the evenings of the 17th, 18th, 19th, and 21st no certain indications of a nebulous light about the star could be detected.

"The spectrum of this star is very remarkable, and leads to unexpected conclusions as to its physical condition.

"The light of the star is compound, and has emanated from two different sources. Each light forms its own spectrum. The principal spectrum is analogous to that of the sun. The portion of the star's light represented by this spectrum was emitted by an incandescent solid or liquid photosphere, and suffered partial absorption by passing through an atmosphere of vapors existing at a temperature lower than that of the photosphere.

"This absorption spectrum contains two strong lines, a little more

refrangible than C of the solar spectrum; a shaded group of lines extending nearly to D; a faint line coincident with D; numerous fine lines up to about the position of *b* of the solar spectrum, where a series of groups of strong lines commences and extends as far as the spectrum can be traced.

"The second spectrum, which in the instrument appears to be superposed upon the one already described, consists of five *bright lines.* This order of spectrum shows that the light by which it was formed was emitted by matter in the state of *gas.*

"One of these bright lines is in the red at the position of Fraunhofer's C. The brightest of the lines coincides with F; a little beyond this is a fainter line; near this line a fourth occurs, which is either double or undefined at the edges. In the more refrangible part of the spectrum, probably not far from G, a fifth bright line was seen by glimpses.

"On the 17th I observed this spectrum of the star simultaneously with the bright lines of hydrogen produced by the induction spark. The brightest line coincided with the centre of the expanded green line of hydrogen. Apparently the red line also coincided with that of hydrogen, but the faintness of the star spectrum did not permit the coincidence to be observed with certainty.

"These bright lines are all much more brilliant than the corresponding refrangibilities of the continuous spectrum over which they fall. We must, therefore, conclude that the temperature of the gas by which the light, consisting of these five refrangibilities only, was emitted, must be much higher than that of the stellar photosphere from which the principal part of the star's light has emanated.

"On the 17th, 19th, and 21st, the spectrum of the star was again examined. No important changes had occurred. In the faint spectrum of the fading star, on the 21st, both spectra could be seen. Some additional groups of absorption lines are probably present in the continuous spectrum, but the gaseous spectrum is not changed otherwise than in the diminution of its brilliancy. The sudden blazing forth of this star, and then the rapid fading away of its light, suggest the rather bold speculation that, in consequence of some great internal convulsion, a large volume of hydrogen and other gases were evolved from it. The hydrogen, by its combination with some other element (the other bright lines do not coincide with those of oxygen) giving out the light represented by the bright lines, and at the same time heating to the point of vivid incandescence the solid matter of the photosphere.

"The grouping of the dark lines of the absorption spectrum is similar to that which characterizes the spectra of *α Orionis* and *β Pegasi*, stars in the atmosphere of which *no hydrogen exists.*

"We have found that several of the more remarkable of the variable stars which have an orange tint have spectra similar to those of *α Orionis.* It is worthy of notice that all the white and bluish-white stars have spectra in which, on the other hand, the dark lines due to absorption by hydrogen are very strong, whilst all the other lines are

thin and faint. These, and other observations we have made, suggest that hydrogen probably plays an important part in the changes and physical differences of constitution of the stars.

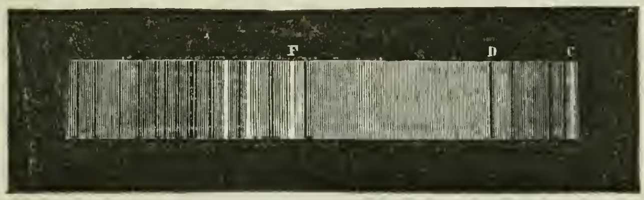
"The grouping of the lines of absorption of this new star shows that its color would be orange, if it were not for the greenish-blue light of the bright lines, which more than makes up for the refrangibilities which have been intercepted by absorbent vapors. Mr. Hinds writes: 'On the 19th, the star was perfectly white and stellar to my eye.' Mr. Baxendell's remarkable powers of observation enabled him to divine some of the results of prismatic examination which at that time were not known to him. He writes: 'On the 18th I several times received the impression of a bluish tinge, as if the *yellow of the star were seen through an overlying film of a blue tint.*'

"On the 17th, the star's exact position was obtained at Greenwich. The Astronomer Royal informs me that a meridian observation showed that this strange object 'agrees precisely with Argelander No. 2765 of 'Bonner Sternverzeichniss,' declination + 26°, magnitude 9·5.' Mr. Baxendell writes to me: 'It is propable that this star will turn out to be a variable of long irregular period, and it may conveniently be at once designated T *Coronæ.*' Mr. Baxendell gives, in his letter, the following table of the magnitudes of this wonderful star:

"'A reduction of all my observations gives the following results:

1866.		h. m.		Mag.
May 15	at	12 0	G. M. T.	T Coronæ = 3·6 or 3·7
16	"	10 30	"	" = 4·2
17	"	11 0	"	" = 4·9
18	"	12 30	"	" = 5·3
19	"	12 15	"	" = 5·7
20	"	12 30	"	" = 6·2'"

Diagram of the Spectrum of Absorption and the Spectrum of Bright Sines forming the Compound Spectrum of the temporarily Bright Star near ε Coronæ Borealis.



MISCELLANIES.

Improvement of the Teasel.—It would seem that no artificial apparatus has ever been found to replace entirely this plant (*Dipsacus Fellonum*) in dressing cloth. M. Gohin proposes, therefore, to prepare the natural head by the same process of mineralization as is used for the preservation of wood. Experience has shown that the heads they prepared lose none of their natural elasticity or delicacy, that they last much longer, and work as well when wet as when dry. The Society for the Encouragement of National Industry at Paris confirms the good report of this application.

Gelatine from Marine Plants.—M. Natalis Rondot made to the same Society a very interesting communication on the subject of the marine plants from which the Chinese procure gelatine, either as an article of food or for use in the arts. The subject would seem to deserve attention from us, both as a means of reducing the price of a valuable article of diet, and as a means of introducing cheaper substitutes for materials of which the large consumption in the arts is raising the price seriously. The same families of plants inhabit our coast, and doubtless gelatine as delicate in flavor, and as strong, could be easily and cheaply prepared from them.

Thermo-electric Piles.—The *Cosmos* gives an interesting account of a paper upon this subject, from which we extract the following tables. In a former article attention was called to the discovery, by M. Becquerel, of the remarkable energy of a pile composed of sulphide of copper and German silver. The following table gives an idea of its power as compared with a Daniell couple, the electro-motive force of the Daniell being reckoned 100.

Difference of temperature of ends.	Electro-motive force.	
	Maximum.	Mean.
100° Cent.	3·40	1·50
200	5·98	3·17
300	8 70	6·03
400	12·63	11·15
460	17·82	16·75
500	21 75	......
800	33·06	......

In order to produce the maximum effect, the sulphide of copper must be annealed by exposure for several hours to a low, red heat. If, however, the heat be brought up to the point of fusion, (1040° Cent.,) the thermo-electric power is entirely destroyed.

The following table gives the comparison between this and other thermo-electric couples, the difference of temperature in the ends of the couples being, in each case, 100° Cent., and the force of Daniell being, as before, considered 100°.

+	—	
Tellurium....................................	German silver.........................	4·121
Sulphide of copper............................	" " (max.)	3·402
Alloy of 806 antimony, 696 cadmium	Alloy 10 Bismuth, 1 antimony......	2·761
" 806 " 406 zinc.......	German silver.........................	1 426
Antimony......................................	Bismuth................................	0·532

From which it appears that the new pile, when carefully made, is more than six times more powerful than the one in ordinary use.

—

Disease of Oysters.—It appears that the oysters of Norway have been subject to an epidemic, which the Institute of Christiana calls "a pestilential consumption," and the result of which is to render the flesh of the oyster a virulent poison, of which many persons have died. Let us hope that their oysters caught cold from being exposed too long to draughts of air, and that, at all events, the disease will not, like the pork trichinæ, extend to other countries.

BIBLIOGRAPHICAL NOTICES.

The Differential Calculus; with unusual and particular analysis of its elementary principles, and copious illustrations of its practical application. By JOHN SPARE, A.M., M.D. Boston: Bradley, Dayton & Co., 1865. 12 mo., pages 244.

Mr. Spare claims for his book that it is the first of any character which has been written and published in America on the calculus, as the special topic of a volume. In this he is evidently mistaken, as the work of Prof. Church, and those of many others, might have shown him. We have carefully examined it, in consequence of the claims to high and exclusive merit which are put forth in the preface, but confess to our inability to find much foundation for such pretensions. It is a well digested and well written work upon the calculus, presenting the subject clearly and comprehensively, but the only great superiority which it shows over other treatises on the same subject, in our opinion, is the great number of admirably chosen examples for application. In this very important respect we are inclined to give it preference to any treatise which we have seen in the English language. F.

Lippincott's Vapor Index.—Mr. Jas. S. Lippincott of Haddonfield, N. J., whose earnest and persevering labors in meteorological science are so well known and appreciated among us, has just sent us a movable table, by which the humidity of the air is at once read off from the indications of the wet and dry bulb hygrometer. The temperatures of the wet bulb are arranged on a fixed rim surrounding a movable disk, upon which are printed in spiral form the differences of the temperatures of the wet and dry bulb. On bringing any given difference to correspond with a temperature in the margin, the relative humidity expressed in hundredths of saturation appear through holes pierced through the disk, and corresponding to the differences of temperature. The arrangement is ingenious and simple, and makes a very elegant and useful piece of apparatus for the meterological student, to all whom we warmly recommend it as saving much time in looking up tables, or in calculation.

A Comparison of some of the Meteorological Phenomena of JUNE, 1866, *with those of* JUNE, 1865, *and of the same month for* FIFTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	June, 1866.	June, 1865.	June, for 15 years.
Thermometer—Highest—degree, .	97·0°	93·0°	98·0°
" date, .	26th.	30th.	29th, '56.
Warmest day—mean,	88·33	85·33	90·50
" " date,	26th.	30th.	30th, '56.
Lowest—degree, .	56·00	61·0	42·00
" date, .	1st.	6th.	5th, '59.
Coldest day—mean,	63·00	65·33	55·00
" " date, .	3d.	6th.	6th, '61.
Mean daily oscillation,	14·27	13·23	16·07
" " range, .	4·67	4·52	4·83
Means at 7 A. M., .	69·32	73·79	68·89
" 2 P. M., .	79·48	83·28	78·89
" 9 P. M., .	72·25	74·73	71·40
" for the month,	73·68	77·26	73·06
Barometer—Highest—inches, .	29·988 ins.	30·069 ins.	30·281 ins.
" date, . .	30th.	6th.	13th, '52.
Greatest mean daily press.	29·937	30·056	30·251
" " date, .	10th.	6th.	13th, '52.
Lowest—inches, . .	29·452	29·589	29·183
" date, . .	18th.	26th.	11th, '57.
Least mean daily press.,	29·502	29·664	29·262
" " date, .	18th.	26th.	11th, '57.
Mean daily range, .	0·101	0·081	0·099
Means at 7 A. M., .	29 750	29·854	29·807
" 2 P. M., .	29·708	29·821	29·772
" 9 P. M., .	29·735	29·841	29·788
" for the month, .	29·731	29·839	29·789
Force of Vapor—Greatest—inches,	0·973 in.	0·848 in.	1·059 in.
" date, .	25th.	30th.	30th, '55.
Least—inches, .	·265	·325	0 162
" date, .	1st.	15th.	5th, '59.
Means at 7 A. M., .	·534	·625	·515
" 2 P. M., .	·555	·664	·537
" 9 P. M., .	·596	·646	·552
" for the month,	·562	·645	·535
Relative Humidity—Greatest—per ct.,	94·0 per ct.	90·0 per ct.	100 per ct.
" date,	3d. & 4th.	9th.	6th, '56.
Least—per ct.,	37·00	39·0	22·0
" date, .	11, 12, & 16th.	15th.	16th, '63.
Means at 7 A. M.,	72·7	74·1	72·1
" 2 P. M.,	54·9	57·9	54·0
" 9 P. M.,	73·7	74·2	70·5
" for the month	67·1	68·7	65·5
Clouds—Number of clear days,* .	11	8	8·3
" cloudy days, .	19	22	21·7
Means of sky cov'd at 7 A. M.,	62·6 per ct.	63·7 per ct.	59·2 per ct.
" " " 2 P. M.,	61·0	65·0	60·8
" " " 9 P. M.,	46·3	43·0	44·6
" " for the month	56·7	57·2	54·8
Rain—Amount, ...	3·390 ins.	4·815 ins.	4·322 ins.
No. of days on which rain fell, .	12	11	11·7
Prevailing Winds—Times in 1000,	s63° 58′w ·282	s30°39′w ·188	s 74° 7′ w ·228

* Sky one-third or less covered at the hours of observation.

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CIVIL AND MECHANICAL ENGINEERING.

On Incrustation of Marine Boilers. By Mr. P. Jensen.

From the London Mechanics' Magazine, May, 1866.

Concluded from page 86.

We come now to a brief survey of the various means proposed or adopted for preventing incrustation. They consist in—

1. Surface condensers.

2. By heating the feed-water to such a temperature before entering the boiler as to oblige the sulphate of lime, and other salts, to accumulate in the heater only.

3. By introducing various substances into the feed-water, before entering the boiler, the feed-water at the same time being subjected to heat so as to throw down the salts without allowing the same to enter the boiler.

4. By introducing various substances into the boiler so as to neutralize the effect of the salts, and

5. By blowing off in the usual or various other ways.

1. *Surface condensers.*—This seems at once to do away with the nuisance. The economy anticipated has not, however, been quite realized in practice. It has been found necessary to inject a little salt water along with the distilled water from the condenser, and the duration of the boiler has been found, in many cases, to be even shorter than with salt water, the reasons for which it is not thought necessary to enter into here.

2. Heating the feed-water, before entering the boiler, to such a degree that the salts are supposed to be thrown down in the heater in-

stead of the boiler. This looks very feasible, but, after all, it amounts to shifting an evil from one place to another; let the heater be choked with salt and incrustation and the engineer in charge has his hands as full as ever. To be admissible on board ship it must be compact, and, at the same time, accessible for thorough scaling, two conditions not very easily reconciled. The most practical shape is that of a casing with a number of dishes or shelves piled on the top of each other in the same, which can be taken out and replaced by clean ones in a short space of time. This plan has been patented by Mr. Spencer (No. 896), and in 1864 (No. 86) by M. L. E. E. Martin, a French gentleman. It is possible that this idea, by no means novel, possesses practical value, and, at some future time, may prove successful.

3. The plan of medicating the feed-water in a heater before it is admitted to the boiler, feasible and correct in principle as it appears, resolves itself, however, into a commercial question, and is contingent upon the price and bulk and other qualities of the substances proposed to be used for neutralizing the salts contained in the feed-water. Many substances have been proposed for this purpose, some evidently not of a harmless character as regards the iron plates of the heater, some evidently so expensive as to be out of the question, and only one or two are of a really feasible character. This latter class will be treated under the next head.

4. The plan of admitting foreign substances into the boiler to neutralize the salts, or some of them contained in the sea-water, has found favor with a great many inventors. Suffice it to say that nothing has appeared more likely, in the eyes of practical and scientific gentlemen, than soda. Mr. J. R. Napier has gone into an estimate of the commercial advantage of using soda-ash for preventing incrustations. He assumes the boiler to work at 270° = 26 lbs. per square inch, and evaporating at that temperature $7\frac{1}{2}$ lbs. water from 100° per lb. of coal. The following is his table:

	Mechanical method.	Chemical method.
Sea-water supplied to boiler at 100°	15 lbs.	8·33
Water discharged at 270°	7·5 lbs.	·83
Water evaporated	7·5 lbs.	7·5
Total heat evaporated from—100° at 270° = 1092 × 5-10th (T_1 32—T_2 32) = 1095	8215·	8215·5°
Heat discharged	1275°	142°
Heat consumed in evaporation	1 lb.	1 lb.
Fuel consumed in preventing crust	·155 lb. coal.	·0172 lb. coal × ·0085 lb. soda-ash.
Total fuel	1·155 lb. coal.	1·017 lb. coal × ·0085 lb. soda-ash.

Thus it seems, he says, that it requires only 172 lbs. of coal + 85 lbs. of soda-ash containing 50° of soda to be as efficient in preventing crust, as 1·550 lb. of coal alone, which evaporates $7\frac{1}{2}$ lbs. of water

from 100° at 270°. And these methods are equally expensive when soda-ash is 16 2 times dearer than coal. This ratio varies with the efficiency of the fuel and the temperature of the evaporation. In this instance the loss by blowing off amounts to 14 per cent. Now, there is no doubt that soda is a very good remedy against incrustations, and it has been repeatedly recommended by eminent chemists. Unfortunately, even this remedy, so simple and efficacious as it has proved, has its drawback, and that of a very serious nature. In a German scientific periodical, *Dingler's Journal*, volume 130, page 153, A. D. 1853, we find it mentioned that Professor R. Fresenius had recommended the use of a certain quantity of soda as a certain and cheap means for preventing incrustations where water is used that contains sulphate of lime (or plaster of Paris). He had used it some months, and with very good results. The factory boiler in question, that formerly used to be scaled at proportionately short intervals, now remained perfectly clean, and even patches of old incrustation too hard for removal had disappeared. But repeated trials and careful examinations had shown that a continued use of soda attacked the boiler-plates very much. Dr. Zimmerman thought that all commercial soda contained more or less cyan, and that this is the reason of the corrosion of the plate. Dr. Rudolph Böttger, who mentions this fact in his *Polytechnisches Notizblatt* of 1853, (No. 20,) says, that he has made several experiments himself, according to which all commercial soda, even from the most respectable firms, contain cyannatrium, and, in consequence of this discovery, he warns others against using it in boilers for the purpose of preventing incrustations. It is important to bear this fact in mind at a time when we find the chief inspector of the Manchester Boiler Association recommending the use of soda in steam boilers. Besides, it must be remembered that such foreign bodies introduced in the boiler produce priming with all its evils.

5. *Blowing off.*—The original practice at sea was, it is believed, to blow off from the bottom only, which was not found efficacious. Subsequently, additional blowing off from the surface was resorted to, and this first at stated intervals and subsequently continuously. Thus we find Henry Maudslay and Joshua Field already in 1824 taking out a patent (No. 5021) for withdrawing a fixed quantity of brine by meters of any kind; they preferred a pump with a loaded discharge-valve drawing from the lowest part of the boiler. They also in this patent mention a tubular regenerator for heating the feed-water by means of the heat of the brine drawn off. These brine pumps were at one time used to some extent, but have now been superseded by the surface blow-off system, because it was found that the pumps and the regenerator got choked with salt and thus became inefficient. Blowing off from the bottom has now become almost superseded by surface blowing off, because the latter plan has been found the more efficient of the two. The impurities contained in the sea-water being, by the application of the heat of the furnace, brought out from the state of chemical solution into that of mechanical mixture in minute particles, floating about in the hot water and steam, are, by the circulation of the steam

and water, floated to the surface in or along with the globules of steam rising to the surface and there held in suspension in the bath of steam and water till accumulating to such an extent as to subside to the bottom, or in their downward course adhering to the surfaces coming in their way. It is hence obvious enough why it has been found advantageous to catch these impurities before they can do any harm and blow them off. Intimately connected with the question of blowing off, is that of sediment collectors. Various sorts have been proposed for this purpose; but it is not proposed to enter into this subject, for the reason that, applicable as they might be for many other sorts of boilers, they are not so, in the author's opinion, as regards marine tubular boilers as now universally adopted, except in the shape of one or two common scum-pans, because any comprehensive system of pipes, pans, and vessels of any sort in the water-room above the tubes would impede the free circulation of the ascending and descending currents, and thus, probably, do more harm than good. The author is, however, open to correction in these remarks, by practical men having actually tried such appliances. And this leads to the consideration of probably the most important element in the prevention of incrustation in marine boilers, viz: the influence that the construction of the boiler itself has upon the subject.

If, as has been shown in the foregoing remarks, the sulphate of lime becomes all but insoluble in sea-water at a pressure of 20 lbs. per square inch above the atmosphere, such as is now commonly used in marine boilers, and if it is a fact, nevertheless, that incrustation can be prevented in some boilers by means of proper and assiduous care, while no amount of care will prevent it in others, then we must arrive at the conclusion that the construction of the boiler, next to the proper and convenient means of constantly observing the state of the water and careful attention to it, forms the most important point in this inquiry. You may build marine boilers of very much the same general internal and external appearance to a superficial observer, and still one is a good and the other is a bad boiler to keep clean and to scale. It is obvious that it is only by the rapid and free circulation of the water and steam that we are enabled to work with salt water at all. It is further probable that, but for the circumstance that the circulation becomes more rapid as you increase the working pressure, and consequently the temperature, higher pressures than 20 lbs., going even as high as 40 lbs., have been found practicable with salt water. The chief principle to be aimed at seems this—wherever the greatest heat is communicated to the plates there also ought to be the greatest facility given for a rapid circulation; and, secondly, make the boiler accessible in all its internal parts, and especially in those most vital, viz: those in which scale, when formed, is most injurious and dangerous, which are those exposed to the greatest heat. The scanty room generally allotted to marine boilers, makes it a difficult task for the designer to meet the above requirements without, at the same time, losing sight of other important considerations, such as economy and strength. The common multitubular marine boiler may be so designed

—and this does not happen very often—that it may give little trouble to the engineer in charge to keep clean and scale it—the tubes must not be too close upon each other, and not too many rows in the vertical line; ample room must be left for a man to get in to clean the furnace crown, the back tube-plate, and the spaces between the tubes. The plan of inclining the back tube-plate somewhat, so as to allow the steam to escape more freely from the same, has found favor with many engineers, and has also collateral advantages. Of late years a multitubular boiler of another description, the vertical water-tube boiler, by Mr. Martin, a chief engineer of the United States Navy, has become extensively adopted in the United States Navy, and possesses, no doubt, advantages as regards scaling the tubes, the water being in them, and the heated products of combustion passing outside and amongst them. This circumstance renders them more easily scaled inside with circular scrapers than is practicable with the tubes in our common marine boilers, that want scaling outside and never can be effectually scaled by mere mechanical means. The Field boiler, now well known amongst engineers, and, because of the very rapid circulation in the tubes possessing the important advantage of keeping the tubes themselves, and also the tube-plate in which they are inserted, free from scale, ought to do well for marine purposes, one should think, although, of course, practice will answer that question. In American men-of-war, where they seem to be able to afford more boiler space than in the British Navy, is often used a long circular return-tube boiler, the tubes being of large diameter (say 1 ft. or more), with very ample water-spaces around and between them. They are, on account of their shape, capable of working with 30 lbs. to 40 lbs. per square inch almost without staying, and also to use salt water at high pressure. Many other boilers proposed or adopted for marine purposes might be mentioned, but it would be to travel beyond the subject to go into the details of this question. To illustrate the importance that has, at all times, attached to this subject, the author here enumerated the more prominent patents that have been taken out in this country for preventing incrustation in boilers. Our limited space only enables us to note a few of the many propositions advanced.

R. B. Lindsay, 1856, (No. 879.)—Applies highly heated steam or air to cause the incrustation to crack, the boiler being cold at the commencement of the process. This method has been tried with great success in the Royal Navy, and seems to offer great advantages where-ever it can be applied.

A. C., L. C., and J. L. Casartelli, 1856, (No. 2623.)—A salinometer consisting of two tubes, the ends of which are supported in two cocks. One cock is marked "blow," and the opposite one "limit." Each tube contains a bead or flow adjusted to certain gravities, that in tube "blow" being lightest. When density of water reaches the gravity of float in tube "blow," the same will rise in tube and indicate that more feed should be admitted, but the float in tube "limit" will not rise till density exceed that of the other to a certain extent. When float in tube "limit" rises, water should be fed in to prevent too great density.

This instrument may also be used as a water-gauge. The annexed plan is not unlike Seaward's salinometer patented many years ago.

Mr. R. Armstrong, 1861, (No. 1472.)—His patent consists of a boiler with a vertical circular fire-box, with oval cross-tubes, whose longest axes are horizontal in the centre and vertical at the end. He has also a plan for a feed-water heater consisting of a cast iron cistern, serving as foundation for boiler to stand on, and the heat radiating from the furnace heats the feed-water. This case is divided into two unequal parts by a partition across reaching to within half an inch of cover or lid, which is to have a thick projecting convexity to dip at least one inch below the surface of water when the larger part is fully charged with feed-water. The water expanding at the surface gradually passes over to top of partition to smaller part; the sediment settles in the larger part. He lines or lags inside of shell with wooden staves, to prevent incrustation.

Mr. R. Needham, 1861, (No. 3285.)—A longitudinal pipe at the bottom of boiler connected to a cock or valve outside. The pipe has, at the bottom, an aperture for entrance of mud and sediment, and at top a number of vertical pipes, each with ventilator-shaped funnel at water-line, with mouth turning towards front of boiler, the flow of water being from the front to the back.

Mr. G. Spencer, 1862, (No. 896.)—On some convenient part of boiler in connexion with the steam-space, a close vessel furnished with a lot of diaphragms or dishes placed one over the other; through the centre or sides of each vessel he brings the feed-water pipe, so that it discharges into the top dish, from which it flows down from one to another through holes or spaces, with raised edges not quite so deep as raised edges round edge of dish. The whole interior is in contact with steam from the boiler. In addition he coats the inside of the vessel and dishes, and the inside of the boiler, with a suitable substance, such as Green's oxide paint, to prevent adhesion of deposited salts to the metal.

After this brief notice of the more prominent patents, it is intended, in conclusion, to mention some of the well-known constructions of salinometers; for if it be true, as seems to be the prevailing opinion among marine engineers, and as it has been shown in the foregoing, that, after all, we must depend more upon blowing off than anything else to prevent incrustation in marine boilers, then the salinometer deserves more than a passing notice. One of the first in order of time is that invented twenty-six years ago by the late eminent engineer, Mr. Samuel Seaward. The instrument consisted of a strong glass tube, about $\frac{3}{4}$ in. bore and 14 ins. long, fixed at each end in a brass frame, to which are attached four cocks, one at each end and two at the side. By the two latter cocks the instrument is attached to the front of the boiler at such a height that the water in the boiler may fill the glass tube. On opening the two cocks attached to the boiler, the water will rise from the bottom of the same by a pipe from the lower cock and fill the glass. On closing these cocks and opening the upper one two balls are dropped into the tube, the first ball being adjusted to one degree

heavier than the water is intended to be maintained at in the boiler, the second ball one degree lighter; then close the upper cock, leaving the communication with the boiler open. Now, if the density of the water should increase beyond the standard adopted, the lower ball would rise, and if it should decrease the upper ball would sink. This is a very ingenious but rather delicate instrument, the use of which has now for many years been superseded by other contrivances. The simplest, though crudest, is one, it is believed, still extensively used in many places, and consists simply in a can or measure, sometimes detached from and sometimes attached to the boiler. This vessel is filled with water from the boiler at certain intervals for ascertaining the density; the water is allowed to cool down until a certain temperature is obtained and found by dipping a thermometer into it, and then the hydrometer, graduated to that temperature, is dipped in, which, by the degree of its immersion, indicates the specific gravity or density of the water. Such an instrument will, of course, fulfill the object of showing the density any time it may be required, but the operation is tedious and requires care, and handling such delicate glass instruments is not exactly the thing in rough weather, when the engineers have many parts of the machinery requiring their constant attention. The next step was the introduction of more practical and complete apparatus, the most commonly known of which is that called How's salinometer. The construction of this instrument will be seen from Plate III., Figs. 6 and 7. How's salinometer case contains a separate compartment for the hydrometer and thermometer, and it is easy enough at any time to let in the water from the boiler so as to fill the case, shutting off the communication with the boiler and blowing off the surplus water, if any; the density of the water when the ebullition has ceased can be read off. But this ebullition, resulting from the reduced pressure of the atmosphere to which the water in the salinometer case now becomes subjected, causes a quantity of hot water to be thrown out of the case, thus exposing the engineer to be scalded; the sudden rush of water from the boiler, if not properly checked by opening the cock very carefully, tends also to throw the hydrometer with great force upwards, causing the danger of breaking it; nevertheless, this instrument has been and is still extensively used.

A more complete salinometer than the preceding one is illustrated by Plate III., Fig. 8. This is the invention of Mr. Long, a chief engineer of the United States Navy. The objections to How's salinometer are obviated in this instrument by the addition of another separate tube. This latter contains a smaller internal tube by means of a cock communicating at the bottom with the water in the boiler while the top is closed, but having small openings near the upper extremity, through which the water can escape in the outer compartment of the long tube or vessel, the steam at the same time freely disengaging itself. The long casing communicates at the bottom with the salinometer casing, which is fitted with a thermometer and a hydrometer. By this arrangement the rush of water and the violent ebullitions are checked, and thus the density of the water can be observed without danger and in-

convenience. But a more convenient and less cumbersome apparatus is represented by Plate III., Figs. 1 and 2. This salinometer, the invention of Mr. Gamble, chief engineer of the steamer *City of Norwich*, has all the advantages of Long's, while the whole apparatus is contained in one piece, thus offering less obstruction, being more sightly and taking up less space in the engine room. This salinometer is now coming extensively into use, and is being manufactured by Messrs. Hayward, Tyler & Co., of Whitecross Street.

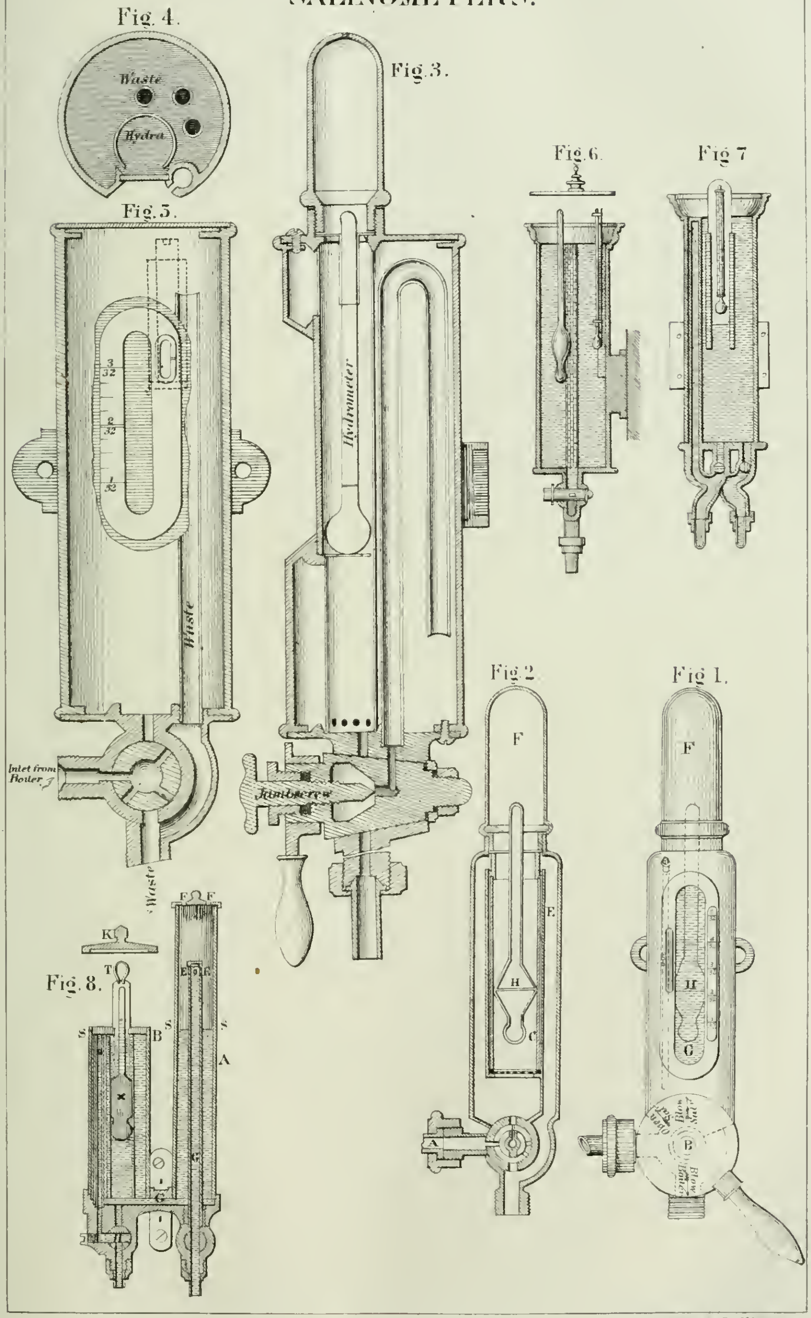
In Plate III., Figs. 3, 4, and 5 is shown an improved pattern of the same apparatus. The water is admitted, through the side entrance of the four-way cock, into the hollow of that cock, and from there, by opening the regulating screw of the jamb-valve, into the bent copper tube in the salinometer case. At the top of the bend is a hole for letting the steam freely escape. By passing through in this way the force of the water is broken, and it will now enter the larger tube containing the hydrometer quietly. That tube is cut open on one side, and a corresponding hole left in the casing, with a glass plate inserted in the same, shows the density of the water at any time. By the side of the hydrometer-tube is a cavity containing the thermometer, the indications of which can likewise be seen through a glass. An overflow-pipe carries the surplus water away. Closing the jamb-valve occasionally and then blowing through from the boiler enables the engineer to clear the supply-pipe from any sediment, and this is an important point. The next operation in starting the salinometer afresh, is to blow it through, which can be easily done by opening the jamb-valve and setting the handle of the four-way cock so that a line on the dial plate points straight through from the salinometer to the waste-pipe; this clears the salinometer and allows the water in the supply-pipe time to cool down before entering the salinometer. 200° Fahr. is the temperature the hydrometer is gauged to. By the regulating screw of the jamb-valve this can be easily and conveniently obtained as well as retained. Another great advantage in this practical little instrument, though it may not at first sight appear to amount to much, is the arrangement of the scales. The indications are given outside the brass face of the instrument where they can be read off instantly. In conclusion, there is no doubt that, after all, blowing off in the proper manner is the best means of preserving the boiler, that there cannot be given the engineer facility enough to do so, and that a salinometer possessing the advantages just described, which are fully borne out in practice, forms the best safeguard against the incrustation of marine boilers.

The Hydraulic Propeller.

From the London Mechanics' Magazine, April, 1866.

The attention of the scientific world has recently been directed to a practical illustration of a system of hydraulic propulsion which has been successfully worked out by Mr. N. W. Ruthven, of Blackwall, in a vessel called the *Nautilus*. In our last number, we briefly noticed

SALINOMETERS.



a private trial of this new principle of motion as applied to the above vessel, and which was attended with highly successful results. No less satisfactory were those which accompanied a run made on Saturday last with the *Nautilus*, from London Bridge to Long Reach and back. We may premise that the vessel was built by Mr. Ruthven at the Orchard Yard, Blackwall, for the purpose of practically proving the advantages of this method of propulsion. Her hull resembles somewhat that of one of the *Citizen* boats; she is of the same length, but much broader and deeper, and fuller in the lines, so that in constructive outline the *Citizen* possesses a decided advantage. She is fitted with two steam engines, each of about 10 nominal horse power, by Mr. Smith, of Wells Street, Oxford Street, her cylinders being 17 inches with 2 feet stroke. Her boilers are of the ordinary type, and were made by Messrs. Camroux & Co., of Deptford. But the point to which our attention is chiefly to be directed is the propelling apparatus, which is based upon the principle of the turbine. It consists of the combination of a centrifugal pump of peculiar form with curved plates, by which the water is drawn into the vessel from beneath her and discharged in different directions. The reaction caused by its outflow drives the vessel in a direction opposite to that in which the water affects its exit. In the *Nautilus*, water is admitted through apertures in the bottom of the vessel into a water-tight compartment in which a horizontal turbine wheel, 7 feet in diameter, is placed, which is actuated from a vertical shaft connected with the two steam cylinders. The wheel is placed below the water-line of the vessel and thus is always immersed. A pipe is taken from the water-space to each side of the vessel, each pipe terminating with two delivery-nozzles, 10 inches in diameter, placed outside at right angles to the pipes, and which, consequently, point fore and aft the ship. A valve is fitted to each delivery-pipe at its junction with the nozzles, and which is actuated from a raised deck built over the engine house for the captain, who, by turning a valve, can eject the water from either nozzle singly, or from both at once. Such, in brief, is the simple apparatus with which the *Nautilus* is fitted, and which possesses palpable advantages over the ordinary methods of propulsion.

We are to examine into these advantages, inasmuch as the success of the *Nautilus* has been very marked, and also because the *Waterwitch*, an iron-cased gun vessel of 778 tons, and 167 horse power, is now being fitted with engines upon Mr. Ruthven's principle. In the first place, there will be no loss of power from slip as with the paddle-wheel or screw, so that with equal quantities of fuel greater power is obtained. In the next place, the engines give a uniform and continuous power, resulting in a smooth motion, so that, all things being equal, there is an absence of vibration, so detrimental to the vessel. Then we have no reaction on the engines from the motion of the vessel in a heavy sea, the propelling power remaining as efficient in a storm as in a calm. Hence the risk of damage to machinery is obviated, and on a long voyage a practical increase of speed or economy of fuel would result. The *Nautilus* is independent of her rudder, and can

be turned on her centre by the propeller alone without the helm and without steerage-way. The motive power is completely under the control of the commander by means of the valves, so that no communication with the engines is necessary for backing or turning. As applied to the *Water-witch*, and vessels of war in general, the hydraulic propeller offers still further advantages. The propelling power being situated within the vessel, the risks to paddles or screws from shot, fouling, or other accidents are avoided. Whatever the draft of water may be, the propeller will work effectively, so, as long as the vessel floats, she must be propelled. Provision is made for shutting off the regular supply of water from the canals, so that in the event of the ship being pierced with shot or springing a leak, the water from the leak is taken up instead for supplying the centrifugal pump. The water would thus be kept under and the vessel propelled at the same time, as with a 500 horse power engine about 1000 tons of water per minute could be discharged through the nozzles. There is a marked difference in the construction of vessels fitted with paddles or screws, and those propelled by hydraulic power. In the paddle-boat we have paddle-wheels and boxes, sponson beams, and the paddle-shaft; and in the screw vessel there is the screw-shaft, screw-tunnel, and the solid wrought iron double stern-post, so costly in large screw vessels, all of which are avoided with the hydraulic propeller. Here is simply a turbine wheel, water-chamber, and nozzles, the cost of constructing which need not exceed that of those parts in the paddles or screw which are dispensed with. These considerations point out that the important element of safety is present in a very marked degree in Mr. Ruthven's system, whilst the appearance of the vessel is much improved, as in the construction of the hull the lines of a perfect sailing ship can be maintained, the propellers in no way interfering with the efficiency of the vessel as such.

The invention of the hydraulic method of propulsion is not a thing of yesterday. Many attempts have been made at various times to accomplish the object, but all endeavors to adopt theory to practice proved futile until Mr. Ruthven, in 1839, invented an apparatus for doing so. A small vessel 9 feet long was constructed about that time, and later on, in 1844, a larger one 40 feet long, both being worked by steam power and fitted with Mr. Ruthven's propeller. These vessels attracted considerable attention at the time, and the Admiralty directed Mr. Murray, the present chief engineer of Portsmouth Dockyard, to experiment with the larger one. Although the results were highly favorable, and although Mr. Ruthven exerted himself to have the invention taken up, it was only a nine days wonder, the inventor's best efforts being unsuccessful. Still, however, he tenaciously clung to his idea of its practical adoption, and in 1849 a few further improvements were made which were subsequently introduced in a vessel about 30 feet long, which was placed on the Thames. It was not, however, until 1853 that the first vessel for commercial purposes was made. This was the *Albert*, which was built in Prussia by a Mr. Sydel, partly at the expense of the Prussian government, the engines and other

machinery being furnished by Mr. Ruthven. This vessel has been employed ever since running regularly on the Oder, where she has proved the complete success of the invention. But, for all this, Mr. Ruthven's patent expired before the principle could be commercially tested in England, so that, in 1863, the Privy Council, impressed with its merits by the practical evidence given, renewed the patent for ten years. This is the only instance on record of such a lengthened period being granted, and may not occur again. Having obtained a renewal of his patent, Mr. Ruthven again set to work to construct a vessel in which the system should be exemplified, and thus the *Nautilus* came into existence. Since the *Nautilus* was commenced the Admiralty have been induced to apply the hydraulic propeller to the *Water-witch*, now being built by the Thames Iron Works Company, and engined by Messrs. Dudgeon, of Millwall. The engines and hydraulic machinery have been designed by Mr. Ruthven, who is also superintending their construction. The vessel is expected to be ready in May next, and will afford an example of the working of the principle on an extended scale.

The trial made on Saturday last with the *Nautilus* was as satisfactory in its results as those which had preceded it. The *Nautilus* ran against the Iron Boat Company's vessel *Volunteer*, of 24 horse power, which she distanced without any apparent effort. That the *Volunteer* did her best was evident from her firing-up, but in order to see that all was fair, Mr. Steel, of the Machinery Department, remained on board of her during the run. As the *Water-witch* is being engined upon the same principle as the *Nautilus*, the Admiralty naturally manifested some anxiety upon the subject, and, although the trip on Saturday was not an official one, several government officials were present to observe and report upon the proceedings. Among these were Admiral Elliot, Mr. Murray, of the Portsmouth Dockyard, and Mr. Steel; Captain Englemere and several other practical officers of the Peninsular and Oriental Company were also present. As the trial was not an official one results of a general character only can at present be given, but when the official run is made we shall hope to lay before our readers the details of working. It may, therefore, be stated that, from the trials already made, it is found that, with the engines working smoothly and steadily, and up to their full speed of 85 revolutions, the *Nautilus* can maintain a speed of twelve miles an hour. On Saturday this vessel, fitted with engines of 20 horse power, certainly distanced the *Volunteer* with 24 horse power, thus proving, at any rate, the soundness of the principle of hydraulic propulsion. Although we must wait for the practical trial at the measured mile for exact results, we may fairly pronounce the trips which have been already made to be highly successful. Constructed on a model unusually full in the lines and with no extraordinary power, this vessel may be considered to afford a severe and reliable test of the principle she illustrates. The steering of the *Nautilus* is effected by a rudder of peculiar construction, which is also the invention of Mr. Ruthven, and applied, for the first time, to this vessel. It is of the usual breadth, but,

instead of being in one piece, it is divided into four parts and held together by joints or hinges. When put over, these parts, by a simple arrangement, form a concave surface to the action of the water, and the water thus deflected presses with great force upon the rudder, by which means the vessel is turned in about one-third the time usually required. The apparatus which actuates the rudder is another creation of Mr. Ruthven's genius, and consists of a working lever on a fixed pin at one end, and with a power applied at the other, but with a link about the middle of it connected with the end of the ship's tiller. The power in the *Nautilus* is a spiral spring, but any other available power can be applied, from a simple pulley and weight to a powerful hydraulic piston. Mr. Ruthven's object is to overcome a difficulty in moving the helms of ships, especially screw steamers, when going at high speeds. So he, by this apparatus, applies an extra amount of power to the tiller, which power can be so regulated as to assist the helmsman to the extent of the water-pressure on the rudder. The rudder is in effect held in a state of equilibrium, the helmsman being thus relieved of the labor of heaving over the helm, and leaving him simply the duty of guiding it. From its construction it will be seen that the apparatus has the further advantage of acting as a counterpoise; and thus prevents the sudden shock to the rudder and flying round of the wheel on the helm being righted or shifted. The apparatus is not necessarily an adjunct of Mr. Ruthven's rudder, and may be applied to any description of rudder. Upon the whole, then, we have to congratulate Mr. Ruthven upon the very successful result he has by dint of patience and perseverance at length achieved. Machinery more simple could not be conceived for the purpose; hence renewals and repairs can never form large items in the cost of maintenance. Judging from what has been done already in testing its efficiency, we may infer the hydraulic propeller is destined at length to assume a position of importance in the world of marine engineering.

The Cycloscope, for setting out Railway or other Curves without the aid of the Transit Theodolite. By Mr. H. Temple Humphreys.

From the London Mechanics' Magazine, June, 1866.

At a recent meeting of the Institution of Civil Engineers, Mr. H. Temple Humphreys, Assoc. Inst. C. E., exhibited and explained, with diagrams, an instrument called the Cycloscope, for setting out railway or other curves without the aid of the transit theodolite, &c. Externally it somewhat resembled a box-sextant. It was composed of two essential parts only, viz: two plane mirrors, one of which was silvered over the whole of its surface, and the other over one-half of its surface. By a law of physical optics, which was called either combined or successive reflexions, a series of images would be formed in the half mirror, which were rendered available to set out any curve of any given radius by applying the eye to an eye-hole in the back of the whole mirror, and, at the same time, setting the two mirrors at an angle to one an-

other equal to the required tangential angle. Then the several successive reflected images of a ranging-rod, for instance, were seen to lie upon the circumference of a mathematically true circle. The curve was then readily set out in the field by simply placing other ranging-rods in line with these several images. This could be done by looking through the unsilvered half of the half mirror, and planting the rods opposite to and overlapping the successive reflexions. No error could arise in the manipulation, and the whole process of setting out a true curve was shortened and simplified. After setting the mirrors to the requisite tangential angle, no further adjustment or support was needed than could be afforded by the top of a ranging-rod placed at the commencement of the curve, and shifted occasionally to any stake on the curve that the limits of distinct vision might require.

Cantor Lectures.—On Submarine Telegraphy. By Fleeming Jenkin, Esq., C.E., F.R.S.

From the London Journal of the Society of Arts, No. 689.

LECTURE I.

The Insulated Conductor and its Properties.—The lecturer stated, that in the lectures he was about to deliver he should aim rather at spreading more widely the knowledge possessed by those practically acquainted with submarine telegraphy, than at announcing the latest discoveries or most novel theories.

Terms used—Conductor, Insulator, Battery, Earth, Circuit, Current.—Some elementary explanations were given with the view of explaining these terms. The action of a current on a magnetic needle, the simplest form of galvanometer and electro-magnet, were shown, with their application to practical telegraphy. The two sources of failure, viz: want of continuity in the conductor, and want of insulation forming a short circuit, were explained. The reflecting galvanometer was exhibited as a means of indicating a feeble current.

The following is a more detailed abstract of the rest of the lecture:

2. *Component Parts of Submarine Cable.*—These are—1st, the conducting wire, generally formed of copper; 2d, the insulator, surrounding the conductor, generally gutta-percha or india rubber; 3d, the outer covering, intended to give strength, and generally formed of a hempen serving, surrounded by iron wires, laid as in a rope round and round the core.

3. *Conductor.*—(*a.*) *Mechanical Properties.*—The conductor is almost universally made of copper, but a solid copper wire is apt to be brittle, breaking after being bent a few times. Interruptions occurred from this cause in early cables. This defect is wholly removed by the use of a strand of several wires, generally three or seven. The tensile strength of copper wire is in some books given as 60,000 lbs. per square inch. That used for submarine cables, being selected for electrical rather than mechanical qualities, will only bear from 35,000 lbs. to 39,000 lbs. per square inch. Copper stretches so much (10, 11, 12, or 15 per cent.) before breaking, that its full strength can

seldom be made use of. This extensibility is, as will be seen, a very valuable property, preventing the interruption of the circuit until the strengthening part of the cable be fairly broken. The following are convenient approximate formulas: A copper strand will bear $1\frac{1}{2}$ lbs. per pound weight per knot before breaking. It will stretch 1 per cent. with 1 lb., and will not stretch at all with 0·75 lb. per pound per knot. Thus a strand weighing 300 lbs. per knot will bearly support 450 lbs., will stretch 1 per cent. with 300 lbs., and will not stretch at all with 225 lbs. The weight of copper in lbs. per knot can be calculated from the diameter d in inches by the use of the following constants: Weight $= 18{,}500\ d^2$ for solid wire, or $15{,}100\ d^2$ for strand. The joint of the conductor is made with great care. A scarf-joint is made by soldering together two filed and fitted ends. This joint is wrapped round with fine copper wire to give it strength, and solder is again run round this wire. A second wrapping of fine copper is then applied, and left without solder. The joint is necessarily less extensible than the rest of the strand. If forcibly torn asunder, the last wrapping of copper maintains the electrical connexion, being simply pulled out like a spiral spring. No interruption from breakage at joints has ever occurred since this system was adopted.

(*b.*) *General Electrical Properties.*—Copper is what is called a good conductor, offering small resistance to the passage of the electric current; that is to say, a much less powerful current would be sent by any given battery through a long iron or lead wire than through a copper wire of equal length and diameter. Table I. gives the relative electrical resistance of several substances compiled from Dr. Matthiessen's experiments. The lower the number the better the conductor.

TABLE I.—*Relative resistance of materials at 0° C. Wires of equal length and diameter.*

PART I.—CONDUCTORS.

Silver, hard	1·00
Copper "	1·00
Gold "	1·28
Iron	5·94
Tin	8·09
Lead	12·02
Brass	4·50
Gold silver alloy	6·65
German silver	12·82
Platinum silver alloy	14·93
Mercury	58·15

PART II.—INSULATORS.

Gutta-percha at 75° Fahrenheit 60,000,000,000,000,000,000	or 6×10^{19}
Glass not less than 600,000,000,000,000,000,000,000,000	or 6×10^{26}

Conduction takes place through the mass, and not along the surface of the wire. A strand and solid wire of equal weights are equally good conductors, but owing to what is termed lateral induction, to be hereafter explained, the strand is at a slight disadvantage for rapid speaking through long submarine cables. Messrs. Bright & Clark,

to avoid this defect, used in the Persian Gulf cable a segmental strand, built up of six wires fitting one another, and drawn through a tube. They hoped thus to combine the advantages of the strand with those of the solid wire. Mr. Thomas Allan surrounds his copper conductor with fine steel wires, to give strength and avoid the use of heavy external protection. In a sample given to the lecturer, the resistance of the conductor so formed was about 30 per cent. more than that of a simple copper conductor of equal weight. Taking induction into account, Mr. Allan's cable would be about 50 per cent. inferior in speaking power to a cable with simple copper conductor of equal weight, and covered with an equal amount of insulating material. This inferiority is not a fatal defect if the cost of the outer protection is avoided. The general merits or defects of this plan will be spoken of in a future lecture. Although the danger of decay where iron and copper meet is known, Mr. Allan's proposal deserves serious consideration.

(*c.*) *Chemical Properties of Copper Wire.*—A current flowing from the copper end or pole of the battery through a hole in the insulator to the sea, causes the formation of chloride of copper, a soluble salt. The copper is thus gradually eaten away, until metallic continuity is interrupted, and the cable ceases to transmit messages. The current from the zinc-pole does not produce this effect, but only a deposit of soda in the fault, which, however then allows a greater leakage, tending to enlarge the hole in the gutta-percha. Mr. C. F. Varley has proposed to twist up a fine platinum wire with the copper strand of long cables. This wire would maintain the communication at any point where the copper might be eaten away.

4. *Insulator.*—(*a.*) *Gutta-percha and Chatterton's Compound.*—Gutta-percha is pressed out, while warm and plastic, through a die round the conductor. Several successive coatings or tubes are thus applied, till the desired thickness is obtained. The first coating is attached to the strand by a substance known as Chatterton's compound, which is also used between each layer of gutta-percha, and between the separate wires of the strand, to prevent the percolation of water along the interstices, in case any part of the copper should be accidently immersed in water.

(*b.*) *Mechanical Properties.*—Gutta-percha has considerable tensile strength, bearing about 3500 lbs. per square inch of section, but, owing to its great extensibility, it does not add more than about one-third of its whole strength to the copper strand. Roughly, it may be said to add in small wires 20 per cent., and in larger cases 30, 40, or even 50 per cent. to the strength of the copper strand. It will stretch 50 or 60 per cent. or more without breaking, but almost always fails as soon as the copper inside gives way. It will bear ill-usage, such as knotting, squeezing, or stretching, without injury, but can be pierced with a sharp instrument, or cut by a knife, without much difficulty. Uniform pressure, such as it sustains under water, improves its electrical qualities, augmenting its insulation resistance, according to Mr. Siemens' experiments, about 60 per cent., at 24° C., for every ton pressure per square inch, corresponding nearly to 1000 fathoms depth

of water. It becomes soft at about 100° Fahrenheit, and should, after manufacture, never be heated beyond 90°. The joints required are made by heating the two ends of the covered conductors after the copper is joined, and applying by hand successive coatings of warmed and plastic gutta-percha. The separate layers of gutta-percha are also cemented by Chatterton's compound. Thus the joint is, when sound, very similar to the rest of the core. Extreme cleanliness and much skill are required in making these joints. Some years since the joints frequently failed, not always when just made, but after some months, becoming hard and brittle, and shrinking so as to leave a gap between the old and new materials. The process is now thoroughly understood, and is a safe one in skilled hands, but in skilled hands only.

(*c.*) *India Rubber.*—This material is applied in many ways. Most commonly tapes of masticated or bottle rubber are wrapped round and round the conductor until the required thickness is reached. At first these tapes were, as it might be termed, gummed together with solvents, but these caused decay, and have been abandoned. Heat is now the common agent for effecting the adhesion. Mr. Siemens, who applied his tapes longitudinally, like two long half-tubes, used simple pressure to join the two halves together. He employed most ingenious machinery to cut the tapes the instant before they were applied to the copper, as the material only reunites if quite freshly cut. Several successive coatings could be applied in this way at one operation. Some manufacturers considered that none of these methods were fully successful, and vulcanized the india rubber, converting it into various materials of different degrees of flexibility, according to the process employed. This material was also criticised, and Mr. Hooper has covered conductors with pure india rubber next the copper, followed by a coating of oxide of zinc and rubber, and enclosed by a vulcanized jacket. In the process of baking the core to vulcanize the jacket, a little sulphur penetrates the india rubber, and the whole mass becomes remarkably compact and durable. Mr. Hooper heats the core to 250° Fahrenheit, and bakes it for four hours. The mechanical properties of these different materials vary greatly. They are all, however, very extensible, and do not add sensibly to the tensile strength of the conductor. They will bear considerable ill-usage, but are mostly softer than gutta-percha, and the pure rubber will not bear continued pressure, even by a blunt surface, but gradually yields. The joints in each form are now made so as to imitate, as far as possible, the main core. Mr. Hooper bakes his joints two hours in a steam-jacket.

(*d.*) *Chemical Properties and Permanency.*—When dry and exposed to light, gutta-percha becomes dry and brittle, losing all its valuable qualities, and is said to be oxidized. Under the same circumstances the various forms of india rubber decay in various ways. Some become treacly, some brittle, some almost friable. Mr. Hooper's hard-covered seems to last best of all in air. When in water gutta-percha is, so far as fifteen years experience can show, absolutely permanent. Many thousands of miles have been laid down, and many hundreds of miles picked up, after lying in the sea in various parts of the world,

in deep and shallow waters, for many years, and not one single yard of material has been found which had, under those circumstances, decayed or lost its insulating properties. The importance of this fact cannot be over-estimated. The experience as to india rubber is the very opposite to this. Little has been employed, and a great deal of that little has been found to decay, so as to be utterly useless. No doubt improvements are continually introduced, and possibly some of the forms now made may answer better, but till the subject is more thorougly understood it would be lost time to reproduce all the theories by which the various failures are explained. Out of five specimens supplied lately to the Indian government, one only (Mr. Hooper's) proved durable even for a year. The lecturer's own experience confirmed this experiment. It must, in justice, be said, that considerable lengths of india rubber covered wire are successfully used on land, supplied by Messrs. Silver and their descendant, the India Rubber and Gutta-percha Telegraph Construction Company, and by Messrs. Wells & Hall. The Indian government has ordered about 100 miles of wire covered by Mr. Hooper's material, which will, therefore, now be subjected to a thorough practical test. India rubber stands heat much better than gutta-percha.

(*e.*) *General Electrical Properties.*—Gutta-percha is a very good insulator. All insulators conduct a little, but the figure written after gutta-percha in Table I. will show the relative resistance to conduction with equal bulks of copper and gutta-percha. A better idea of the vastness of the number will be obtained by observing that light would take a century to travel through the number of feet which that number would express. The practical result of this degree of insulation with the Atlantic core is that more than 99½ per cent. of the current leaving England would reach America if the cable were but laid. Any improvement in insulation will, therefore, only go to diminish this half per cent. loss, in itself of no consequence whatever. India rubber has a higher resistance still. The chief advantage to be obtained from this high resistance is the facility it gives for detecting faults. India rubber is, however, superior to gutta-percha in another electrical property, called its inductive capacity. More words per minute, in the proportion of 4 to 3, at least could be sent through an Atlantic or other long cable insulated with india rubber, than if insulated with gutta-percha, the weight of insulator and conductor remaining the same. This point will be more definitely treated of hereafter.

(*f.*) *Absorption of Water.*—Mr. Fairbairn long since stated the superiority of gutta-percha to india rubber for deep sea cables, owing to the comparatively small quantity of water which it absorbs. Probably the newer forms of india rubber may have improved in this respect, but Mr. Siemens found that pure india rubber absorbed 25 per cent., vulcanized rubber 10 per cent., and gutta-percha 1½ per cent. of their weight in pure water. These quantities were reduced to 3, 2·9, and 1 per cent., respectively, in salt water. The absorption continued for 300 days. It was 8 times greater for india rubber at 120° of Fahrenheit than at 39°, but for gutta-percha it was only doubled

by the rise in temperature. Mr. Siemens considered that pressure affected the absorption very little. The amount absorbed by gutta-percha in no way damages it. This is proved by thousands of miles of submerged cables; for instance, the tests of the Malta Alexandria cable, laid four years since, under Mr. Forde's superintendence, by Messrs. Glass & Elliott. Part of this cable supports about half a ton per square inch pressure.

TABLE II.

	No stretch.	One per cent. stretch.	Breaking strain.
	lbs.	lbs.	lbs.
Atlantic core	340	414	660
No. 14 copper covered to No. 1, 107 lbs. copper, 166 lbs. gutta-percha	134	162	218
No. 16 copper covered to No. 4, 73 lbs. copper, 93 lbs. gutta-percha	100	120	150

TABLE III.—*Dimensions of cores of important cables.*

Name of Cable.	Copper conductor.		Gutta-percha.		Approximate ratio $\frac{D}{d}$.	Log $_\varepsilon \frac{D}{d}$.
	Total weight in lbs. per knot.	Total diameter of conductor $= d$.	Weight in lbs. per knot.	Diameter in inches $= D$.		
Red Sea cable	180	0·105	212	0·34	3·4	1·224
Malta, Alexandria, standard	400	0·162	400	0·457	2·95	1·082
Persian Gulf	225	0·109	275	0·38	3·48	1·249
First Atlantic	107	0·083	260	0·38	4·8	1·57
Second Atlantic	300	0·144	400	0·464	3·28	1·19
England and Holland	143	0·095	223	0·34	3·47	1·244
Toulon and Algiers	107	0·083	223	0·34	4·26	1·45
Varna, Balaclava	73	0·062	166	0·3	4·84	1·58

5. *Mechanical Properties of Completed Core.*—Few persons are aware of the great strength of the common gutta-percha covered wire. An experiment was shown by the lecturer, in which 5 cwt. was hung from the slender looking core of the new Atlantic cable. It stretched some 10 per cent. under this weight, and was then taken down, knotted, squeezed, and cut open, when the copper conductor appeared quite undisturbed in the centre of the gutta-percha, which exhibited no trace of injury. Before the application of Chatterton's compound,

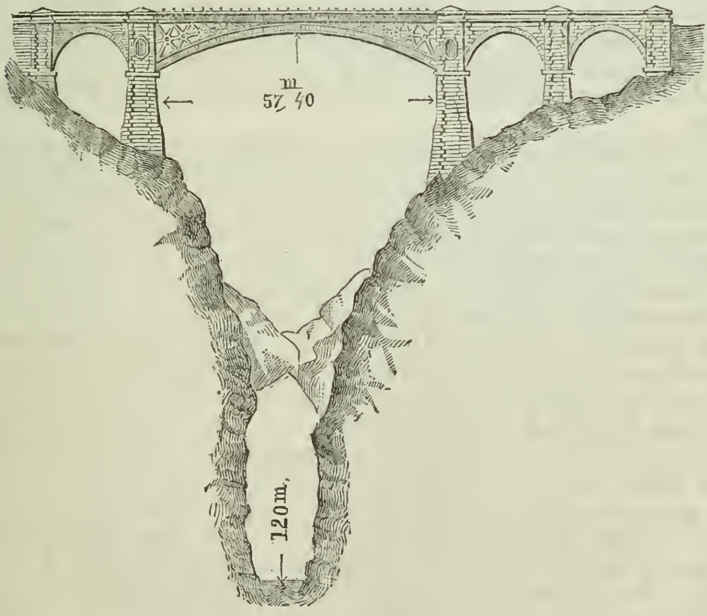
the wire was liable to start out of the cable after it had been stretched and cut, or softened, owing to the unequal elasticity of copper and gutta-percha, but with Chatterton's compound considerable force must be used to drag out the copper wire, even when the core has been stretched and is cut open. Table II. shows the strains which various wires can support.

Table III. gives the dimensions of the cores in some of the most important cables laid. It is noteworthy that 300 miles of the very smallest core practically in use, laid without any outer protection whatever, maintained our connexion with the army for nine months during the Crimean war.

(To be continued.)

Cast Iron Bridge near Constantine, (Algiers.)

We copy the design of a very graceful cast iron bridge, thrown by a French engineer, M. Martin, over a deep and precipitous ravine, near Constantine, (Algiers.) The span of the main arch is 57·4 metres (188 feet) in span, and the depth from the roadway to the bottom of the ra vine is 120 metres, (393 feet.) The only novelty of any interest about the construction was the method taken to support the centering of the



arch. As the depth was so great, and the bottom occupied by a torrent liable to sudden and destructive floods, the attempt to build up a support from below would have been both expensive and hazardous. The engineer, therefore, threw four cables across the chasm, two on

each side of his proposed bridge, from which he supported a platform, on which the arch centering was built. The wooden centres, when finished, found their support at their abutments, and the suspension bridge was retained only for the service of the work, and the iron arch-stones were never permitted to rest upon it.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

The Working Processes for the Reduction of the Gray Copper (Tetrahedrite) Ores at Stefanshütte, in the Comitat (County) of Zips, in Hungary. By J. L. Kleinschmidt.

(Continued from page 132.)

In a second trial, I precipitated, after the separation of the copper by hydrosulphuric acid, oxidation of the fluid, etc., the ferric oxide, partly by carbonate of soda, and then, after filtering, the rest by soda lye. The precipitate thus obtained was melted with metallic arsenic, cyanide of potassium, and black flux in a crucible, (tute,) but no globule was obtained. Iron and copper were separated in the nitric acid solution by ammonia in the usual way. The ferric oxide was dissolved a second time in hydrochloric acid, and to the solution ammonia added in excess. The copper, by titration in the ammoniacal solution, gave 25·95 per cent.; add to these 0·98 per cent. from the SbO_4, we get 26·93 per cent. of copper. 0·0200 grs. gave 0·0027 grs. ferric oxide, equal to 9·1 per cent of iron. The silver was ascertained by cupellation.

The iron pyrites ores (kiese) which are added to the melting contain lead, but in several experiments I have not succeeded in finding it in the crude speiss, (rohspeise,) but I found it in the slags of the copper refining, (Spleissabzüge;) therefore the lead has a greater affinity to the sulphur, and remains in the matte, and does not go to the speiss.

Crude Matte, (*Rohlech.*)—This was digested with nitric acid until all sulphur was dissolved, then diluted with water. The residue, after settling, gathered on a filter, and while yet wet, digested with concentrated muriatic acid, to which, afterwards, water and tartaric acid were added. The residue, which was not dissolved by the muriatic acid, was gathered on a filter, and weighed after ignition. This, consisting of slag, was examined before the blow-pipe, by melting with cyanide of potassium, but no reaction of antimony was obtained. The diluted solution was precipitated by hydrosulphuric acid, after it had been warmed to the boiling point with sulphurous acid, in the last determination the precipitate dried, weighed, and calculated as tersulphide of antimony. The original solution was measured, and in one portion of it the sulphur determinated by precipitation with chloride of barium, and the precipitate several times boiled with muriatic acid. Iron and copper were determinated as mentioned above, the silver by cupellation.

Crude Slag, (*Rohschlacke.*)—This was decomposed by melting with

carbonate of soda and chlorate of potash in a platinum crucible. It was found that nothing of the crucible was dissolved by the operation, if in the separation of the melted mass from the crucible no acid was employed. The mass was supersaturated by hydrochloric acid, evaporated to dryness, and in general proceeded as in the analysis of silicates. It was not possible to decompose the slag perfectly by digestion with hydrochloric and some nitric acids. At first I made use of this method, because I feared the platinum crucible would be injured by the fusion with chlorate of potash, but it was necessary to decompose the resulting silicic acid once more by fusion with carbonate of potash. It is not possible to prepare the slag by washing, because most of the interspersed matte would, on account of its greater specific gravity, remain at the bottom. The fluid, separated from the silicic acid, was boiled with sulphurous acid, to reduce the ferric oxide, and then precipitated by hydrosulphuric acid, the precipitate gathered on a weighed filter, after weighing burnt, and then dissolved either in nitric acid, and the ammoniacal solution titrated by cyanide of potassium, or, after roasting, to remove the sulphur, melted with cyanide of potassium, carbonate of soda, and some borax, and the copper globule rendered pure before the blow-pipe by melting it with some borax-glass. A trace of oxide of cobalt added to the melting mass, acts, in the refining of the copper, as indicator, and it can be easily evaded, that any trace of copper goes into the slag. I found the latter method for slags more reliable than the wet way, where it is difficult to know if there are not traces of copper retained with the antimonious acid, although, by the solution of the hydrosulphuric acid precipitates, I obtained always the latter perfectly white. The copper is then calculated as sulphide of copper, and the antimony from the difference. The other substances were determinated in the usual way.

Roasting of the Matte.—The mattes are roasted in pieces of about 2 inches diameter, in oblong heaps, in the open air. There are brought in one heap 1000 to 1500 cwt. of matte, and in the first roasting, by 12 feet width, they are made of such a length that the matte is 1½ feet thick on the thin layer of wood. At every succeeding fire the heap is made shorter and higher, more and more wood is taken, and from the fifth or seventh fire, accordingly as the roasting has advanced, a layer of charcoal is added to the upper part of it.

In this manner 10 to 13 fires are given, and the mattes are considered only then as being well roasted, if they form a black, porous, light mass, which may contain metallic copper, but no undecomposed matte. In the last fire the roast forms a quadratic pyramid of 10 to 12 feet length of the sides, and 8 to 9 feet high. Lately it was the intention to try the roasting in covered stadeln, (roasting places surrounded by a wall.) My experience in Mexico and Ducktown, Polk Co., Tenn., have convinced me, that the roasting of the mattes and ores, where it is done as a preparation for the melting in shaft furnaces, and where it is not necessary to condense volatile products, is done best in the open air.

Melting of Roasted Matte, (Rostdurchstechen.)—The well-roasted

mattes are mixed with 20 per cent. of raw quartzy ores, containing from 3 to 4 per cent. of copper. By this melting are obtained: Black *copper*, with 80 to 84 per cent. of copper, and 3 to 4 ounces of silver; upper matte, (*oberlech*,) with 50 to 60 per cent. of copper, and 1 to 2½ ounces of silver and slags. The furnace used for this purpose measures from the tuyeres to the mouth only 8 feet. The other dimensions are the same as those of the furnaces for crude melting, (rohöfen,) but there are no boshes. The furnace has two tap-holes, the one for the black copper on the side, the other 10 inches above the first, in the middle, for the matte. From the lower tap-hole an iron kennel leads to a water-basin, in which the tapped metal runs, and hereby becomes granulated. The matte runs by the tapping to a sump pool, as in the crude melting; first the matte is tapped and then the black copper; the consumption of roasted matte is about 10 tons in 24 hours.

The produced black coppers (schwarz-kupfer) have a fine grained fracture, and almost silver-white color, and form bluish, clustered, blistered masses and grains; and because they are to be stamped and reduced to powder, a certain amount of antimony is needed, to give them the necessary brittleness; if they contain more than 87 per cent. of copper, they can only with difficulty be stamped and ground.

The composition of Phönixhütte oberlech, (matte obtained by the melting for black copper at the Phönixhütte,)—

S	22·25
Cu	60·00
Fe	16·52
Sb	0·10
Slag	1·50
	100·37

Schwarz-kupferschlacke (Black Copper Slag of the Stefanshütte.)

SiO_3	31·70
FeO	62·33
Fe	3·00
Cu	0 87
S	1·23
CaO	0·44
MgO	0·10
	99·67

Schwarz-kupfer der Stefanshütte, (Black Copper of the Stefanshütte.)

	Produced May, 1864.	Produced Oct., 1864.
Cu	83·10	86·50
Fe	2·80	3·50
Sb	13·35	8·46–8·03
S	1·05	1·05
Ag	0·25 (4 oz.)	0·25 (4 oz.)
Co. and Ni	traces.	traces.
	100·55	99·76

The upper mattes, (oberlechs,) differ always in their amount of copper. They were not analyzed, but in their weekly assays they show almost the same per centage of copper as those of the Phönixhütte, from which, except in their yield of silver, they cannot differ much. Like these they contain fine threads of metallic copper in the pores. Their amount of sulphur, therefore, is less than that of the crude matte, (rohlechs.) The oberlech (upper matte) are added to the roasts of the crude mattes in the fifth fire.

The slag of the melting for black copper, (rostchlacke;) it was already above mentioned that it is added to the crude melting as flux, where likewise is given the composition of it. It flows over the slag drift; therefore it contains less copper than that of the Phönixhütte, where black copper, matte, and slag are tapped together. It never contains undissolved pieces of quartz, proving that the quartz is easily turned into slags, if only the necessary bases are present, and the furnace is constructed in such a way that the ferrous oxide goes into the slag, instead of becoming reduced. With the produced speiss and the black copper, (schwarz-kupfer,) the melting work balances its accounts. The products are weighed, assayed, and given over to the amalgamation works.

Amalgamation of the Black Copper, (*Schwarz-kupfer Amalgamation.*)—The granulated black coppers are stamped beneath iron stampers, then ground, first between iron mill-stones, then between stones of granite. The powder must be as fine as the finest flour. After having been mixed with 10 per cent. of common salt, it is placed upon the upper hearth of a reverberatory furnace of the known Hungarian construction, as they are now in use in Saxony, the Hartz, &c. On this it remains for five hours, during which time it must be constantly stirred. It is then lowered down to the lower hearth by an opening which connects both. The fire in the first two hours is only slow, so that in the upper furnace, which has no direct fire, the charge requires at least two hours before getting dark red-hot, in which low state of temperature it must be kept during the next three hours remaining there. On the lower hearth the fire for the first two hours must be so slow that the glowing is visible only at night, and then the heat is, in the following two hours, increased to bright red heat, which, in the fourth hour, comes near to white heat. In the last (fifth) hour, the fire is moderated so as to draw out the mass at dark red heat. In the upper as well as in the lower furnace, the charge must be stirred and turned continually, and although the black coppers are not very easily rendered fluid, there is attention required, particularly in the upper furnace, that no lumps are formed and masses adhering to the bottom of the furnace. It is not enough to have converted the silver perfectly in $AgCl$, to which a much less degree of heat would be sufficient, but it is necessary to decompose so much as possible the sulphuric and antimonial salts. If this is not done it will result in a great loss of quicksilver, and the residues remain too rich in silver.

The outdrawn powder, after cooling, is separated from the lumps, which may have formed, by sifting. The latter are added to the

roasting of the next charge in the upper furnace without previous grinding. In this state they show themselves more profitable, because they loosen the black copper powder, and prevent that it accumulates. The sifted powder is then ground very finely, and given into the amalgamation casks in quantities of 12 to 15 cwt., according to their size, and mixed with such a quantity of already used lye from the reservoir (see below) warmed to 86° to 122° Fahr., (in winter it wants to be warmer than in summer,) that the quickmud (quickbrei) thus formed has the consistency of thin honey.

In filling the casks, which contain already 100 lbs. of copper balls, 10 to 15 lbs. of common salt are added to strengthen the lye. Generally some quicklime is added to it, to saturate the acid, and to decompose partly the metallic salts, which in most cases are in too great a quantity in the lye and the roasted black copper. Then the casks are slowly turned around their axes for about half an hour, when a trial is made, as follows: Some of the quickmud (quickbrei) is put in a glass cylinder, diluted with water, well mixed, and then put away for one hour. The powder must settle in this time perfectly to the bottom, and the supernatant lye be clear and almost without color. This not being the case, the quickmud contains free acid, and more lime or ashes must be added. When the quickmud is found to be in the right condition, 400 lbs. of quicksilver are added, and then the casks moved around their axes for 18 hours. After this time a sample is assayed by cupellation. If in 100 lbs. of the residues only $\frac{1}{16}$ of one ounce of silver is found, the cask is emptied, otherwise the operation is continued. The mercury containing the silver is taken from the cask, filtered through a cotton flannel bag, the more solid amalgam which remains pressed by a hydraulic press to separate as much as possible the free quicksilver, and then distilled in a cast iron retort, whereby the quicksilver is reobtained. The pressed amalgam contains only 18 per cent. of silver. After the distillation of the quicksilver, the silver is melted in the same retort, scummed, and then cast into ingots. It contains only 2 to 3 denär = $\frac{1}{16}$ to $\frac{3}{32}$ ounce of copper in the mark, or 8 ounces. After the separation of the mercury the cask is emptied, the powders separated from the copper balls by a sieve, washed several times, and when they have settled and got consistent, they are taken out and brought to the melting furnace. The lye, which is used again in filling the casks, is put in large reservoirs, in which it is kept for further use.

Melting of the Residues of the Black Copper Amalgamation, (Rückstand-schmelzen.)—The residues, when brought to the furnace, contain 16 per cent. of water. They are mixed with 20 to 50 per cent., as they are in store, of not fully roasted "gelf-lechs," (matte containing no silver,) of latter processes, and 10 to 15 per cent. of poor quartzy ores, together with 20 to 30 per cent. of slags of the melting of roasted matte for argentiferous black copper, and melted in one of the same furnaces, which are used for the crude melting, (rohschmelzen.) In building the melting works a stamp mill with drying stove had been provided, to mix the residues with clay or quicklime, but

this was not continued very long, and the residues are now given to the furnace, as they are, with 16 per cent. of water. In consequence of the moisture, and the pulverulent state of the mass, the melting proceeds very slowly. Formerly some pyrites were added instead of the partly roasted matte, but thereby a very inferior copper was produced. The products of this melting are gelfkupfer, (copper free of silver,) oberlech, (upper matte,) and slag.

The composition of them is:

Rückstand Schwarz-kupfer. (Black Copper produced from the Residues of the Amalgamation of Black Copper of May, 1864.*)

Cu	85·90
Fe	4·20
S	0·55
Sb	9·35
	100·00

Rückstand Schwarz-kupfer Schlacke, (Slag from the Melting of the Black Copper Residues after their Amalgamation, May, 1864.)

SiO_3	38·20
FiO	57·60
S	1·47
Cu	0·50
Sb	0·30
CaO	1·34
MgO	0·38
	99·79

The black copper of this melting has more the aspect of black coppers as they are produced on other melting works. It is very difficult to break it to pieces, fracture hackly, color white, here and there changing into yellow and gray. These black coppers almost always contain iron, from which sometimes only traces are to be found in those which are argentiferous. When free from iron, the copper may go into the slag, although the yet considerable amount of antimony prevents this to some degree. The slag stands, in respect to the amount of silicic acid between roh and rostslag; getting cold in thin pieces it is almost glassy, in thick pieces the fracture is smooth, pillar-like almost, color bluish-black, runs well on the slag drift, and contains very few grains of matte.

The oberlechs (upper matte) were not analyzed. They contain in their cavities a great deal of copper in form of threads. Their per centage amounts to 50 to 60 per cent. They are roasted with 4 to 7 fires, and given to the next melting of the residues of the black copper amalgamation. The melting of these residues is very troublesome for the workman on the mouth of the furnace, because there is a continuous volatilization of terchloride of antimony. The whole space before the mouth of the furnace (schichtenraum) is very often full of a dense white smoke, which seriously affects the lungs, and causes vomiting. When the vapors escaping at the mouth of the furnace do not burn with flame (dark mouth) the smoke is still more intolerable. The slags are thrown away, but the black coppers come to the

* Ni, trace. Co could not be found. Sb from the loss.

Spleissen.—This is done in a spleissofen (spleiss furnace, reverberatory furnace) of the Hungarian construction. In the beginning the melting was done with generator gases in furnaces constructed in the manner of an English copper-melting furnace, but so many difficulties occurred, and, at the same time, the smelting was so expensive, that the old method was taken up again. The hearth of the spleiss furnace is formed of stamped talcose slate, mixed with yellow loam. When yet damp it is beaten in and covered with pine brushes, whereupon the black copper is laid. A charge consists of 30 to 50 cwt., and the pieces are arranged in such a way that they offer an ample passage to the flame. The warming lasts 48 hours; then follow 10 to 12 hours of slow firing, in which the copper glows only dark red, after which time it commences to melt together. Until this time no wind is given, but now the same is turned on, and the fire increased to melt the slag. This lasts 2 to 3 hours. The slag melted, the copper begins to boil, then the wind is moderated, and the slag drawn from the copper by a wet piece of wood fastened to an iron bar. This slag, first drawing, (1ter abzug,) is very refractory, has a dark color, and can be drawn only with difficulty from the furnace. It consists mostly of the earthy masses, which adhere to the spleiss chips, which are returned into the furnace. As soon as the slag is drawn, and the copper appears with a bright surface, a dense smoke emanates from it, and the copper is now in the state which is called the "schwefeln," (emanation of sulphur,) sulphurous acid emanates, the wind is quite turned off, and the fire moderated, so that the copper for about two hours is quietly left alone. During this time copper, in form of a fine dust, is thrown up constantly from the melted metal. As long as this fine dust is visible, no wind can be given, because by doing so copper dust would be blown out of the furnace. When the copper begins to become quiet, some wind and more fire is given, and both are increased for about 8 to 10 hours until the copper is tapped. In this period every hour the slag must be drawn. As soon as this is done a great deal of antimonial smoke escapes. During the last hour, when by an increased wind the fire must be very strong, the slags are drawn every quarter of an hour. As soon as no white smoke emanates from the copper, it is stirred up with green birch poles, (poled,) and wet pieces of wood are made to swim on the copper. All these coppers must be driven very high to produce a good copper by refining lastly in an open hearth, (gussherd.) The quickly cooled proof (gaarspan) on the interior side must be of a pink color without dark spots, the outside dark brown, the edge (grat) thick and rounded, not thin and sharp. If all these tests are found perfect, the wind is turned off, and the copper is tapped. It flows by two tapholes in the warmed vortiegel (pits in the form of crucibles, cut in a mixtûre of loam and charcoal, which is stamped in a space before the tapholes, inclosed by iron plates,) then water is thrown at the surface of it. The cold disks or cakes (spleissen) are taken off by a fork (forkel) and thrown into cold water. The cakes thus obtained are sold only in small quantity as such, but most of them as refined into hammered plates, (hammergaare platten.) To

that end they are melted in an open hearth, made from stamped talcose slate and some loam, and as soon as the copper is refined (gaar) it is cast by a ladle into moulds. Yet red-hot are these brought beneath a water hammer, and are forged until their thickness is only two-thirds of the original. When the copper in the hearth smokes, the hammer-master drives it above the refining point, and reduces it again by stirring it with a wooden pole (poling), and let it then come to the right point again, and repeats the operation if necessary.

The "hammergaare rückstand-kupfer" (refined copper from the residues of the black copper amalgamation) thus produced has the composition:

Cu	98·99
Sb	1·01
Ni	trace.
	100·00

This can be hammered without getting edge-cracks, and can be rolled to thin plates. There is a great demand for it in Austria, and it is preferred to many other brands.

The slag of this process (gaarschlacke) contains, separated from the grains of metallic copper dispersed in it, of suboxide of copper, 12 per cent. = 10·5 per cent. of copper, and 0·6 per cent. of antimony. It is of a red-brown color, blown up like foam, and difficult to melt. The copper from the crucible assay of this slag contained neither nickel nor iron. The slag is added to the melting of the residues from the amalgamation. The residue of 150 tons of crude speiss and 200 tons of refining slag has to be worked up by itself yearly, and this forms the most difficult part of the melting operations.

Working up of the Speiss.—Amalgamation.—The speiss is powdered, and a charge of 700 to 900 lbs. is placed into a roasting furnace. Commencing with a slow fire on the grate, this is removed entirely as soon as the speiss begins to glow, and the roasting is performed at the lowest possible temperature. The charge is then taken out, the furnace cooled down, no fire at all given to the grate, and a new charge put in. This in a short time begins to glow, and has to be constantly stirred and turned, and every attention paid that the furnace does not get too hot. In this manner the roasting is conducted for months, without fire on the grate, because there is so much heat remaining in the walls of the furnace, that each new charge begins to glow by itself. The furnace is recharged every 8 hours. The speiss powder, after cooling, is sifted, the lumps are ground, both powders mixed, and turned over to a second roasting. 600 lbs. of this powder roasted without fire are mixed with 100 lbs. of crude speiss, put into the upper furnace, and remain there, being constantly stirred and turned for 5 hours. The crude speiss is added for the purpose of easier setting the mass on fire in the upper furnace. In the fifth hour there are added in the upper furnace, to this charge of 700 lbs., 100 lbs. of crude limestone. After the fifth hour it is lowered down to the lower hearth, where it is mixed with 3 to 4 shovelsful of charcoal dust.—

This is done three times from the fifth to the seventh hour. Now the grate is fired; and in the ninth hour the mass must be bright red-hot; therefore a pretty good fire is kept up, which is extinguished again at the end of the tenth hour; so that can be reckoned in the upper and lower furnace together as follows:

Incension, no fire on the grate	1 hour.
Calcining, (schwefeln,) no fire	7 hours.
Roasting, good fire, bright red heat	$1\frac{1}{2}$ hour.
Cooling, no fire	$\frac{1}{2}$ hour.

The firing is done by chips and pine branches. It is necessary that during the whole process of roasting the charge be constantly stirred and turned; therefore the upper and lower furnace are furnished each with two workmen, who alternately do the work from hour to hour.

The powder comes from the furnace in a sheet iron wagon, in which it is transported to a corner of the roasting house, where it cools off entirely. 700 lbs. of it are mixed with 49 lbs., or 7 per cent., of salt and 6 lbs. of crude limestone, and then it is given to the lower hearth of a furnace, where it is roasted for 4 hours at dark red heat, which is somewhat increased during the last hour. Chloride of silver is here formed without sulphuric salts being present, which emanate sulphuric acid, and thereby decompose chloride of silver. Then the amalgamation is done quite in the same manner as the amalgamation of the black copper.

On Magnetical Errors, Compensations, and Corrections, with special reference to iron ships and their compasses. By Professor Airy.

From the London Athenæum, April, 1865.

(Concluded from page 109.)

V. *Magnetism of Ships, especially of Iron Ships, and Correction of Magnetic Disturbing Forces on the Ship's Compass.*—54. Notes on the principal steps made in the investigation of these subjects, by Flinders, Christie, Barlow, Sabine, (for wood-built ships containing some iron;) by the Astronomer Royal's experiments on the *Rainbow* and *Ironsides;* by Scoresby, Liverpool Committee, Towson, Rundell, Evans, (experiments and approximate theory for iron-built ships;) by A. Smith, (inferences from Poisson's general theory, change in the form of the numbers exhibited, and theory of the parallel needle compass.) Speci treatises, "Admiralty Manual," edited by Captain Evans and Archibald Smith, Esq.; "Practical Information," by John Thomas Towson, Esq., published by the Board of Trade. The latter is strongly recommended to nautical men.

55. For theoretical purposes, and for steering a ship, (in a very contracted range of latitude,) by a table of errors of compass, it is necessary to measure the disturbance of the compass in numerous positions of the ship. For the practical purpose of correcting the compass, it is only necessary to place the ship in a limited number of positions; eight (at the utmost) at first, and two in subsequent alterations.

56. Methods of measuring the disturbance of the compass: By observation, with azimuth sights, (at great height above the compass, if necessary,) of a very distant mark, whose true bearing by compass is known. By similar observation of a celestial body, whose astronomical azimuth can be computed and can be converted into magnetic azimuth. (For this purpose a knowledge of the local variation is necessary; it can be taken from Captain Evans' very valuable chart. By reciprocal observations of azimuths with an azimuth compass on shore in a position free from disturbance, (a method practised by the Astronomer Royal for the *Ironsides*, and frequently used since that time.) In circumstances where none of these methods can be used, by observation of a moderately near mark, accompanied with observations which define the position of the compass, and by repeating the observations nearly in the same places upon a wooden raft (as practised by the Astronomer Royal for the *Rainbow*). The selection or invention of the method to be used must be left to the judgment of the operator under the actual circumstances.

57. Methods of conveniently recording the disturbances: By table of errors. By Napier's diagram, with equatorial triangles. By concentric circles.

58. Investigation of the deviations in the *Rainbow*, in which the existing theory was first established. General obscurity on the subject. Deviations of the steering compass amounting to 50° marked end drawn to the east, and 50° marked end drawn to the west, according to the position of the ship's head. The first light thrown upon it was derived from observations of the vibration of a magnet freely suspended in the place of the compass, the observations being made with the ship's head N. E. S. W. The vibrations of the same needle were observed on shore. By comparison of these, the proportion of the acting magnetic force on the ship's compass in those different positions of the ship to the earth's undisturbed magnetic force was found. (The acting force with the ship's head nearly south was ten times as great as with her head in the opposite position.) Thus it was found that, representing the earth's force by 100 towards the north, the ship's polar force was represented by 80 towards the stern, and 17 towards the port side, or by 82 in a direction 12° from the stern. (This is the largest that has yet been observed.) By a graphical construction with these elements, based on the parallelogram of forces, it was found that the observed disturbances were accurately represented, with the exception of a small quadrantal quantity, such as would be produced by the iron of the ship nearly towards the head, or towards the stern, (Article 30.) A magnet of proper intensity was prepared and placed in the proper position to correct the ship's solar force, and a scroll of iron was placed on one side (Article 46) to correct the quadrantal deviation, and the compass was then sensibly perfect.

59. Treatment of the deviations in the *Ironsides*. In this operation was invented the method of using two magnets instead of a single one; a most important step, because it gave the means of effecting the correction without calculation. The ship's head was placed magnetic

north or south, by the aid of a shore compass viewing her masts, and a magnet was placed on the ship's deck in an athwart position, ahead or astern of the compass, and was slid nearer or further till it caused the compass to point correctly. Then the ship's head was placed magnetic east or west, and a magnet was placed in a fore and aft position on the deck on one side of the compass, and was slid nearer or further till it caused the compass to point correctly. The first magnet does not disturb the compass in the ship's second position, and the second magnet does not disturb the compass in the ship's first position. Thus the compass was made correct in the four cardinal positions of the ship. Then the ship was placed in an intermediate position, her head 45° east of north, or west of north, and a mass of iron was placed on one side of the compass to correct quadrantal deviation. Then the compass was sensibly perfect. This is the process which is still universally employed. The object in placing the magnets either below the compass or broadside-on is to avoid introducing a vertical force, which is produced with a magnet end-on, (Article 22.)

60. Exhibition of the process of correction in a model.

61. Description of the different substances which have been adopted for correction of the quadrantal deviation; scroll of iron plate, small box filled with fine iron chain, masses of cast iron, &c.

62. Continuation of history. After a time it was found that the polar magnetism of a ship, which was supposed to be permanent, was not really permanent, and the term "subpermanent" was introduced; in particular, reasons appeared for supposing that the polar magnetism changed rapidly in the course of a ship's first voyages. The Liverpool Committee was appointed to inquire into the whole subject; their three reports are probably the most valuable documents that we possess referring to these questions. The inquiries were conducted principally by Mr. Towson and Mr. Rundell. Among their most important conclusions were these: That the direction of a ship's polar magnetism, as affecting her compass, might always be inferred from the position in which she was built; that, therefore, it was to be concluded that her magnetism was induced by subpermanent magnetism (Articles 37, 38, 39) produced by the hammer blows in uniting the plates when building; that much of this was soon lost, when the ship was afloat, but that a part remained, with little alteration, for many years. The Astronomer Royal discussed the records of several ships of the Royal Navy, and also those of the Royal Charter, and showed that after the first voyages the change of polar magnetism was small, and generally in the nature of diminution. (Dr. Scoresby's special observations on the Royal Charter had no important relation to the ship's compass.)

63. Very important observations on this matter were made by Captain Evans and Mr. Rundell on the *Great Eastern*, which they followed through several stages after its launching. The transversal polar magnetism diminished very greatly.

64. Among the points elicited by the inquiries of the Liverpool Committee was this, that in many, but not in all, of the merchant ships which they examined, the correction of the compass effected in Eng-

land failed so much in southern latitudes as to lead to the impression that the ship's polar magnetism had changed considerably. As far as had been observed, there was no similar change in ships of the Royal Navy. Remarking that in merchant ships the compass is nearer to the stern than in ships of the Royal Navy, Mr. Rundell was led to a practical conclusion which ought, in all cases, to receive attention. The history of an earlier discovery is first to be mentioned.

65. Captain Flinders, who made a voyage of discovery in a wood-built ship in the first years of this century, remarked with great accuracy the errors of his compass, with the ship's head in different directions, and with the ship on different sides of the magnetic equator, and with singular sagacity referred their cause to the induced magnetism in the vertical iron stanchions, (Article 27,) which were principally ahead of the compass. He suggested that they might be corrected by placing a vertical iron bar astern of the compass. General Sabine, in discussing later voyages, remarked that the change due to position on the globe did not *immediately* follow the change of ship's position; which showed that the magnetism of the stanchions, &c., partook in some measure of the nature of subpermanent magnetism, (Article 37.) These remarks nearly exhaust the subject of disturbances in wood-built ships.

66. Mr. Rundell, apparently without any knowledge of Captain Flinder's proposal, remarked that the compass of merchant ships is not far in advance of the great vertical iron bar of the stern-post, accompanied in screw steamers by another bar of the rudder-post, and that a magnet which corrected the influence of these bars in north latitudes would increase it in south latitudes, but that a correction valid in all latitudes might be made by fixing a vertical iron bar ahead of the compass. This has been done in several instances, apparently with uniform success. The amount of correction to be produced ought probably to be such as will leave the fore and aft magnetism at that place nearly similar to that on other parts of the ship.

67. The disturbance of the compass is undoubtedly simpler when a ship has been built with her keel in the magnetic meridian, but there does not appear to be any strong reason for deciding between the positions of head north and head south.

68. After every care has been taken, the ship's subpermanent magnetism will change, (usually diminishing slowly,) and arrangements ought to be made for meeting this change. Nothing appears preferable to Gray's adjustable binnacle.

69. For the application of this, it is necessary to be able to place the ship's head once north, (or south,) and once east, (or west,) using for this purpose either a land mark or a celestial body. The dumb card is the most convenient instrument for placing the ship's head in the proper position.

70. Adverting now to the quadrantal deviation. In merchant ships the quadrantal deviation is usually 3° or 4°, or perhaps in a few cases 6°, and in nearly every case it is of that kind which would be produced by a mass of iron exactly ahead or exactly astern of the com-

pass, (Article 30,) and this may be corrected by a mass of iron placed exactly on one side, or by masses placed exactly on both sides, (Article 46,) and an error of 6° is not too great, especially when the four-needle card is used, to prevent this from being done conveniently.

71. But in the armed ships lately built for the Royal Navy with iron decks and iron in every part, the quadrantal deviation amounts to 14°, and it is difficult to correct this by a mass of iron.

72. Perhaps it might be corrected by another compass, (Article 47,) but the same correction would not be valid in different latitudes. (Article 50.)

73. The Astronomer Royal prefers a modified card. (Article 53.)

74. It has lately been discovered by Captain Evans, that in the wood-built ships covered with the thickest armor plates, the quadrantal deviation is small, not exceeding 3° or 4°. This is analogous to what is described in Article 29. It appears to show that the riveting of the plates of an iron-built ship produces what may be called "magnetic contact," but that the juxtaposition of large masses of iron does not produce magnetic contact. In the latter case, the simple theory of the Astronomer Royal, (*Phil. Trans.*, 1839,) appears preferable to the general theory of Poisson. The form of their results is the same, but the co-efficients are different.

75. In the turret ships lately built it has been necessary to place the compasses out of the central line of the ship's deck. That eccentric position modifies the law of quadrantal deviation in this way, that the quadrantal deviation is represented by the effect of a mass of iron not exactly ahead or exactly astern of the compass, but in a direction somewhere intermediate between the fore and aft direction and the transversal direction. The difference which this would make in the correction would be the following: After having adjusted the transversal magnet to make the correction complete with the ship's head north, the correction would be found incomplete with head south; and the adjustment must be altered till the error is divided between the two positions. In like manner with head east and head west. By remarking the magnitudes of the residual errors in different positions, the operator will determine with considerable accuracy the direction of the ship's head when the error is 0; and the mass of iron must be either towards north or south, or towards east or west, with the ship's head in that direction. That choice of positions being determined for the mass, the ship must be turned 45° from the same direction, and the mass is to be adjusted to make the compass correct. A modified card might be adapted to the compass, but it would require a special commencement of readings.

76. The order of operations ought in all cases to be this: (1.) For a compass near the stern, Rundell's vertical bar ought to be fixed. (2.) The two magnets, or systems of magnets, for effecting the correction with the ship's head N.E.S.W. ought to be applied. (3.) The masses of iron for correcting the quadrantal deviation ought to be applied, or the modified card ought to be mounted. These will never require alteration, whatever alteration be made in the magnets. (4.) The ship

should, if possible, be sent on a short voyage, or should be exposed to agitation by the sea, and to tremor by her machinery, in different positions of her head, for several days. (5.) The positions of the magnets ought to be readjusted. It will probably be sufficient to place the ship once with her head north, (or south,) and once with her head east, (or west.)

77. *It is of very great importance that the ship should not be hurried out immediately for a long voyage, but that she should be exposed to agitation and tremors, with her head in different directions, several days at least, and that her magnets should be readjusted before sailing on a long voyage.*

78. On the voyage, the captain should be prepared to readjust the magnets, as is described in Articles 69 and 59, (omitting all that relates to correction of quadrantal deviation, which will never alter.)

79. Some of the methods described in the Admiralty *Manual* relate to the determinations in different localities, and at different times, of the principal elements of magnetic disturbance, as the error of the lubber-line, the subpermanent or other polar forces towards the ship's head and the ship's side, the apparent direction and measure of action of the masses which act by induction, (Article 30,) and the loss of directive power, (Article 35.) In instance of the importance of these determinations it may be pointed out that in iron ships of the Royal Navy the loss of directive power is from one-eighth to one-sixth of the whole. These methods are of the highest value for the philosophical investigations connected with compass disturbance, and are strongly recommended to the advanced mathematician; but they are not likely to be useful in the merchant service.

80. Others of the methods in the *Manual* relate to the possibility of converting a table of errors determined for one locality into a table of errors applicable to another locality. It does not appear probable that such a process can ever be used in the merchant service.

81. On the general question of "correction or non-correction" of the compass, the arguments appear to stand as follows: (It is to be remarked that, if the ship's subpermanent magnetism undergoes a change, it affects both systems with equal injury, and, therefore, that occurrence is omitted in the comparison.)

Non-corrected Compass. *(Using a Table of Errors.)*	Corrected Compass. *(The Binnacle being adjustable.)*
The directive power on the compass is extremely different on different courses.	The directive power on the compass being sensibly constant.
The principal part of the tabulated errors arises from subpermanent magnetism, whose effects in producing deviation vary greatly in different parts of the earth, (Article 20.)	The magnets which perfectly correct the subpermanent magnetism in one place will also perfectly correct it in another place.
It is, therefore, absolutely necessary from time to time to make a new table of errors by observations in numerous positions (not fewer than eight) of the ship's head.	Only when there is suspicion of change in the ship's magnetism are new observations necessary, and then two are sufficient, (Article 69.)
In difficult navigation, as in the chan-	In any hydrographical difficulty, the

nels of the Thames or the Mersey, especially with frequent tacks, the use of a table of errors would be attended with great danger. corrected compass is right on all tacks of the ship, and its use is perfectly simple.

82. The Astronomer Royal has no hesitation in giving his own opinion that the compasses used for directing the ship's course ought to be corrected, and that the efforts of scientific men ought to be directed mainly to the rendering this correction rigorously accurate and easy of application. But the captain, who desires to make his voyages really serviceable to magnetic science, must have one compass on board which either is not corrected, or whose correction is never altered, and must frequently observe it, not for the purpose of steering his ship, but for the collection of magnetical facts. This, however, is to be considered as a philosophical experiment, not as an aid to navigation.

83. The disturbances and their corrections, as treated up to this Article, apply to a ship on even beam, or without any heel; and, by using the methods above described, there is no difficulty whatever in making the correction sensibly perfect. The heeling, at present, offers considerable difficulty, not in estimation of its magnitude, or in application of a correction at any one place, but in doing this in a way which will apply at all parts of the earth.

84. The general law of the effect of heeling is this: When a ship's head is east or west, no sensible effect is produced by heeling. When the ship's head is north or south, heeling produces the greatest effect. Usually, but not in all cases, the marked end of the needle is attracted to the windward or raised side of the ship in north latitudes, and the unmarked end in south latitudes. Usually, in iron ships, with ship's head north or south, one degree of heel produces one degree of disturbance of the compass; but in some instances one degree of heel produces two degrees of disturbance of the compass.

84*. The disturbance by heeling appears to arise immediately from these separate causes:

(1.) Part of the action of the subpermanent magnetism is perpendicular to the deck, and this has not been touched by the operations of correction of the forces in the plane of the deck (if the magnets are applied broadside-on). When the ship heels, this untouched magnetism is inclined to the horizon, and produces partly the effect of horizontal magnetism, and thus disturbs the compass. If the blue end of the magnetism perpendicular to ship's deck is uppermost, it will attract the marked or red end of the compass.

(2.) If there are masses of iron fore and aft of the compass, and also masses of iron to starboard and port of the compass, and other masses added for correction of quadrantal deviation, the masses fore and aft will produce no new effect from heeling, but the masses to port and starboard will be raised on the windward side and lowered on the leeward. The red end of the former, which is its lower surface, will be nearest to the needle, and will repel the marked end; and, in like manner, the upper or blue magnetism of the mass on the lee side will attract it.

(3.) A mass near the ship's keel, considered in the the same way, will have an effect opposite to that of (2), but agreeing with that of (1.)

(4.) A transversal deck-beam nearly under the compass will, on being inclined by the heeling, have blue magnetism in its higher end, which will attract the marked end of the compass, agreeing with (1) and (3). It appears that in most instances the aggregate effects of (1), (3), and (4) exceed that of (2).

85. Attempts have been made to separate these various effects by theoretical considerations, but their success appears doubtful.

86. There appears to be no safe way of determining the amount of the effect of heeling, except by making the ship to heel, and observing how much the compass is effected, either by heaving her down (in dock) or by subjecting her to the action of the wind (on a river or sea).

87. In all cases the effect can be corrected by fixing a magnet below the compass in a position perpendicular to the deck. For, when the ship heels, this magnet becomes inclined, and a portion of its magnetism acts horizontally, and can be made (by trial) exactly to neutralize all the other effects.

88. Gray's binnacles are adapted to receive such a magnet, and to give power of adjusting it. It is carefully to be remarked that this magnet must be mounted and adjusted *after* fixing the masses of iron used to correct quadrantal deviation, (Article 61.)

89. Either the magnet may be adjusted in position while the ship is inclined, or the following course may be pursued: By means of a "clinometer," the ship's inclination may be observed while experiments are made on the deviation, and thus a proportion may be obtained between the angle of heel and the angle of deviation. By means of an experimental pendulum, (whose axis passes through the centre of a compass-card,) on which a magnet can slide, the position may be found at which a magnet will produce the same proportion between the angle of heel and the opposite deviation. The distance of this from the centre of the experimental card is the distance at which the same magnet must be fixed below the ship's compass.

90. On a voyage into southern seas, these experiments ought to be repeated.

90*. And, as a general rule, a corrected compass ought to be considered available in the same manner as a chronometer for longitude. Very great reliance may be placed on it for even very long distances, but it ought to be checked at every possible opportunity.

91. For experiments on iron ships, the following apparatus (among others) may be found desirable: Two or more azimuth compasses, (prismatic compasses also are sometimes convenient.) A dumb card. A vibrating needle for horizontal intensity, either suspended by a silk fibre, or in the form used by Captain Evans. A deflexion needle for horizontal intensity, in Mr. Towson's form. A vibrating needle for vertical force, in Captain Evans' form. A dip needle, balanced to a definite angle, for vertical force, in Mr. Towson's form. An ordinary dipping needle. A clinometer, or pendulum, with graduated arc. A pendulum adapted to carry a magnet. Magnets. Iron for induction experiments. Magnetic anvil.

On National Standards for Gas Measurement and Gas-meters.

By George Glover, Esq.

From the London Journal of the Society of Arts, No. 424.

(Continued from page 123.)

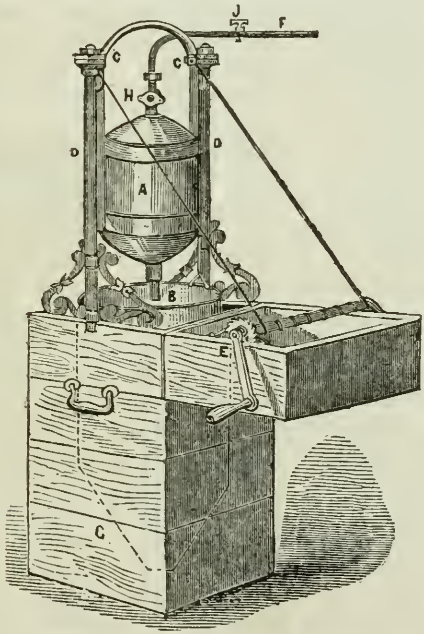
The national standard gas-holders were made at the works of Messrs. Bryan Donkin & Co., whose well-known accuracy in workmanship, and perfect machinery for drawing truly cylindrical tubes of large size, recommended them for such an undertaking. They were constructed under my direction and constant superintendence. In constructing the instruments, the various properties of gas I have just named had to be taken into account, and the following conditions were laid down as essential:

1. That they should be composed of a non-corrodible metal, capable of resisting the chemical action of the constituents of coal-gas and water.
2. That the surface of the bell should readily part with water.
3. That the bell, or measuring part of the instrument, should be a truly cylindrical vessel, and sufficiently rigid to resist change of form from the application of any ordinary forces.
4. That it should have a correct scale engraved upon it to indicate its capacity in cubic feet, and the subdivisions of the feet into minute fractional parts.
5. That it should be correctly balanced, and that a part of the counterpoise, suspended by a cord passing over a spiral, should preserve its equipoise at various depths of its immersion in the water in the cistern.
6. That the sides of the bell should be maintained vertical in its ascent and descent.
7. That the taps should be lined with the anti-corrosive alloy, and the density of their rubbing surfaces be so varied as to reduce their friction to a minimum, and secure their durability and soundness.
8. That the different parts of the instrument should be so perfectly adapted to each other, that, when put together as a whole, it should work easily, steadily, and correctly.

The standards having been constructed, the next point of difficulty was the application of the cubic foot bottle in graduating them. Their graduation involved nice scientific considerations, and a series of experiments requiring much delicacy and care. I may here state, that in the graduation and experimental adjustment of the standard gas-holders, I received most valuable assistance from Mr. William Græme Tompkins, C.E., who was afterwards employed at the Exchequer in the application of the standards in the verification of the gas-holders for testing meters furnished to the local authorities, and in this his engineering knowledge and experience in the manufacture and use of instruments of precision was of great service. Though the cubic foot bottle already described was accurately adjusted for containing the "legal standard and unit of measure," there was no method known by which it could be used in measuring gas, or in the graduation of

holders. An instrument called a "transferrer" was resorted to. It consisted of "an upper chamber, containing exactly the volume of one cubic foot, and adapted, with proper arrangement of cocks and pipes, by repeated discharges of the water filling the upper chamber into the lower chamber, to discharge in succession any number of volumes of air, each of one cubic foot, into any vessel properly prepared for their reception." This instrument was resorted to without any satisfactory result. It was open to serious objections. The filling of the bottle produced agitation of the water, displacing air from the water, and entangling variable quantities of it in minute bubbles, many of which adhered to the inner surface of the bottle. Every means which suggested itself was tried to make it available, but these giving no satisfactory result, it was laid aside. Analogous methods were tried of

Fig. 2.



GEO. GLOVER'S DIRECT TRANSFERRER.

Scale $\frac{4}{10}$ inch = 1 foot.

A. Inverted cubic foot bottle.
B. Cistern to be raised.
C C. Small pulleys for rope-connecting windlass with cistern.
D D. Pillars to support cubic foot bottle, and to which the pulleys are fixed.
E. Windlass with ratch for raising the tank or cistern.
F. The exit pipe from bottle.
G. The box in which the whole instrument is enclosed.
H. Window covering the aperture made by the withdrawal of the plug of the tap of the bottle.
I. Tap betwixt bottle and holder.

transferring the exact cubic foot of air to the gas-holder, but with hardly more success. A closer approximation in some instances was obtained, but the uniformity was not such as to justify their adoption in the division of the scale. At last it occurred to me that, instead of using the bottle indirectly, it might be used directly, the second vessel being dispensed with. The diagram, Fig. 2, will explain the process.

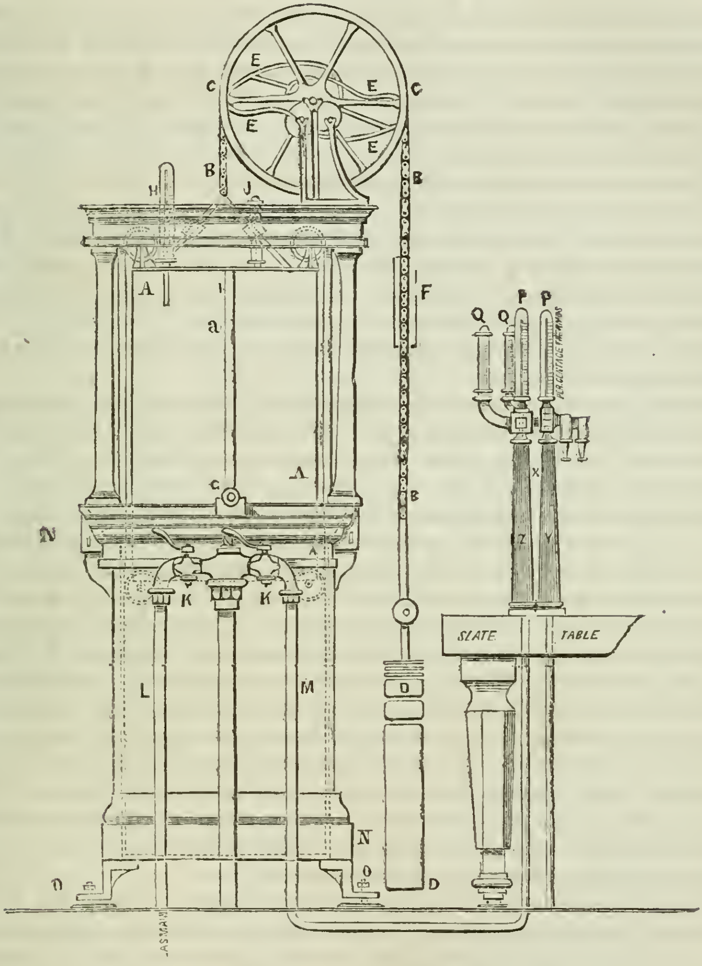
1. The bottle was inverted.
2. The plug was drawn out.
3. The openings caused by the withdrawal of the plug were closed with glass.
4. A piece of leaden tube was soldered to the end of the tap.
5. This tube was connected with the gas-holder to be tested.
6. A cistern containing distilled water was placed below the bottle thus secured in a fixed vertical position.
7. The cistern was raised steadily, without the water being agitated, through the entire length of the bottle, until the water reached the point where the plug of the tap, had it been retained, would have stopped it, and the entire volume of air, viz: one cubic foot, defined by the contents of this bottle, was found to have been transferred to the gas-holder.

By this method, simple and direct, the various errors occasioned by the complicated character of the "indirect transferrer" are at once avoided. Tested by numerous experiments, the results of this method have been invariably satisfactory, and it has removed a difficulty long felt by meter makers in the graduation of their holders for testing meters. In his letter to the Lords Commissioners, from which I have already quoted, the Astronomer Royal, referring to it, says: "The volume of air defined by the contents of the cubic foot bottle was forced into the gas-measurer, Fig. 3, under trial by a process invented and introduced by Mr. George Glover, in which the nearly undisturbed surface of water is carried gradually through the entire length of the bottle without risk either of absorbing or giving out air. For the one-foot gas measurer this operation, in strictness, was required only once, (but, as a cautionary step, it was repeated several times.) For the ten-feet gas measurer it was necessarily to be done ten times. The result of the examination was that the five-feet measurer exhibited no trace of error; that the ten-feet measurer appeared to show an error of about $\frac{1}{3000}$ part, which appeared to be undoubtedly due to a little change of temperature; and that the one-foot measurer, which is extremely sensitive to such changes, apparently exhibited errors, sometimes $+\frac{1}{500}$, sometimes $-\frac{1}{500}$. Regarding these indications as merely illusory, I do not doubt that the gas measurers are as accurate as it is possible for human skill to make them, and I therefore report them as being, to all intents and purposes, perfect."

The experience of five years, I am happy to say, has only confirmed this testimony.

In verifying holders, and in testing meters, thermometers of a peculiar construction, Fig. 4, are used with elongated bulbs, by which sufficient delicacy of indication is insured, whether of the testing room,

Fig. 3.



A A. Inverted cylindrical vessel, commonly called the bell.
a. The scale engraved on the bell.
B B. Chain or band by which the bell is hung.
C C. Wheel or pulley over which the chain or band works.
D D. Counterbalance weight for the bell; upper parts movable, so as to give the two pressures required by Clause 13 of the Act.
E E. The cycloids or spirals fixed on the pulley-shaft, and balancing each other.
F. A counterbalance weight attached to the extremity of one of the cycloids to maintain the true balance of the bell at varying depths of the water.
G. Microscope for reading the scale.
H. Thermometer on the bell.
J. Pressure-gauge on the bell.
K K. Taps.
L. Inlet pipe.
M. Outlet pipe.
N N. Cistern or tank.
O O. Adjusting screws for leveling cistern.
P P. Thermometers on testing-table.
Q Q. Pressure-gauges on table.
Y. Exit column from secondary.
Z. Exit column from standard.

the standard bell, the outlet of the standard bell, or the outlet of the instrument being tested. On one side of the thermometer is a scale for temperature, on the other a scale for corrections rendered necessary by variations of temperature and moisture in the gas. The scale is calculated from the tables for temperature and moisture kept at Greenwich Observatory during a period of twelve years, and Mr. Glaisher kindly assisted in rendering these instruments more perfect, and in carefully comparing them, throughout the whole scales, with the standard thermometer at the Observatory.

Thermometers in general use vary to a large extent, not only from each other, but from themselves, in different parts of the scale. Gas, as you know, expands about $\frac{1}{4}$ per cent. from temperature and moisture for every degree of Fahrenheit's scale, *i.e.*, in round numbers, about 5 per cent. for 20 degrees. Gas coming out of the ground at the temperature of 40° would increase 5 per cent. in this room if the temperature were 60°.

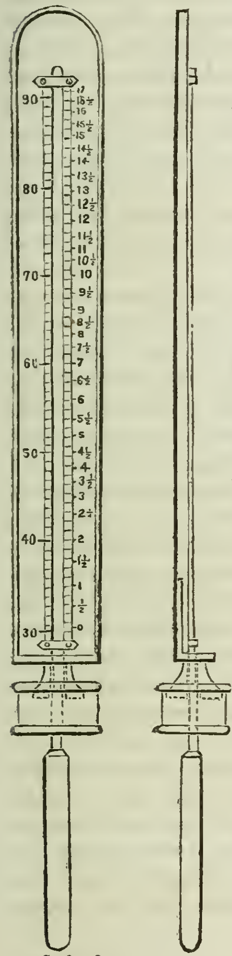
In fixing a unit of measure, and providing standards of measure of the highest attainable accuracy, the "Sales of Gas Act" has rendered a great and valuable service. And here I am reminded of the language employed by the famous Laplace, when speaking of national standards for weights and measures generally: "We cannot reflect on the prodigious number of measures in use, not only among different nations, but even in the same country, their capricious and inconvenient divisions, the difficulties of determining and comparing them, the embarrassments and frauds they occasion in commerce, without regarding, as one of the greatest benefits, the improvements of science and the ordinances of civil government can render to mankind, the adoption of a system of measures, of which the divisions being uniform, may be easily derived in calculations, and which may be derived in a manner the least arbitrary from the fundamental magnitude indicated by itself. A nation that would introduce such a system, would unite to the advantage of reaping the first fruits of the improvement the pleasure of seeing its example followed by other countries, of which it would thus become the benefactor."

And so, in the present instance, we are already reaping the fruits of the "Sales of Gas Act." A great advance towards correct measurement has been effected. The inaccuracy of the meters in general use hitherto has been fully established. The companies and the community can now be protected. So far the legislature has done its duty. Lord Redesdale's Act carried legislation as far as the present state of our information justified, and it avoided the grave error of going beyond it. The prudent and wise course for government to pursue is clear. It is at once its duty and its interest to protect, encourage, and give every facility to a manufacture now so intimately connected as gas is with the public welfare.

And here, I may remark, in passing, that the clamor now being raised against gas manufactories being conducted in the heart of our

cities and towns is unreasonable. It has gained strength from the recent explosion of a gas-holder not far off, a circumstance which has excited needless apprehensions. No occurrence could be more exceptional. I believe it is without precedent, and it arose from a circumstance which might easily have been prevented. When, in 1854–55, I had the honor to be instructed by Sir Benjamin Hall (now Lord Llanover) to examine and report on the gas-works of the metropolis, for his guidance, with reference to the "Nuisances Removal Act," I reported that gas-works could be conducted in populous neighborhoods without being a nuisance or injuring the public health. Legally to constitute a nuisance three things must be established: A noxious element in sufficient quantity; that element in sufficient intensity and in continuous action; and gas-works were not declared such a nuisance. To science, in fact, and not to legislation, must the public look for the removal or mitigation of any evil or danger which they may occasion.

Fig. 4.



Scale of Temperature.

The right hand column of figures shows the per centages due to temperature and moisture.

But to return. The government having done its duty, it should be the endeavor, as it is the interest, of meter manufacturers to produce meters such as will satisfy the just demands of the public. The work of reform in the measurement of gas which emanated from the legislature must be carried on systematically and earnestly throughout the community. Neither party interests nor party prejudices can be permitted to obstruct the public weal. Old monopolies here, as in other kinds of manufacture, injurious in the first instance to the public, and eventually to the monopolists themselves, must be considered among things that were, and the principle of free and unrestricted competition—"a fair field and no favor,"—as the only principle which can secure the benefits the "Sales of Gas Act" was meant to yield. Mere slop work, the bane of every other kind of manufacture, must be done away with in this. Slovenly workmanship, bad materials, "rough and ready," "finger and thumb" adjustment, whether of the wet or the dry meter, must give place to careful execution, suitable materials, and correct mechanical adaptations.

In respect to the wet meter the following points may be considered as clearly established: That, with the introduction of water, the proverbial instability of water is introduced; that the level of the water is disturbed by the pressure of the gas constanly varying; that the

use of the wet meter exposes the companies to severe loss, and those who use them to annoyances and dangers from which dry meters are comparatively exempted; that corrosion from the action of the constituents of coal-gas and water is actively at work, and fatal to their durability. Of late it has become customary to make cases of cast iron, to conceal the corrosion, without reference to what is going on internally, and, by repeated coatings of green paint, to convey the idea of soundness, an idea which is simply delusive. Mr. Hawksley, whose knowledge and experience on every subject connected with gas entitles his testimony to much weight, stated before a committee of the House of Lords that, in 1864, in the Nottingham gas-works, 330,000,000 of cubic feet of gas had been made, and that 50,000,000 of cubic feet of that quantity had not been paid for.

No doubt he attributed a considerable portion of this loss to over consumption in the street-lamps, and to leakage. The public will be astonished when told that, even at present, most companies acknowledge that, of the whole gas manufactured by them, from 15 to 20 per cent. is lost or unpaid for, a loss which is usually ascribed to leakage. Most gas companies, as a rule, have no correct method of ascertaining the exact amount of loss; but, whenever the question is carefully gone into, and accurate methods of measurement applied, the loss out of profits is found to be from 20 to 25 per cent., and, in some instances, even more. About 15 per cent. of this loss may fairly be put down to defective meters. The tenacity with which many companies have clung to the wet meter, and their efforts to maintain it, have been in no small measure owing to the want of a suitable substitute, and the failures which, with one exception, have marked the history of the dry meter manufacture. These failures may be traced to one or other of the following sources: The inadequate scientific knowledge of the manufacturers themselves; the complexity of the conditions the manufacture involves; the error of adopting angular movements in the measuring chambers instead of direct action; the use of rotary valves; the difficulty of arriving at the combination of metals in such definite ratios as to constitute a true alloy, the uniform density and structure of which shall be such that, when manufactured into a D slide valve, the rubbing surfaces shall wear equally, and the perfect soundness of the valve shall be maintained.

(To be continued.)

Recent Researches on Metals and Alloys. By Dr. F. Crace Calvert, F.R.S., F.C.S.

(A Lecture delivered May 16, 1865.)

From the London Journal of the Society of Arts, No. 677.

The importance of the subject which I intend to bring before you this evening is so extensive, that it ought to be the subject of a series of lectures instead of attempting to condense it into one, and therefore I shall only give a *resumé* of some of the discoveries which have been made during the last two years.

You are probably all aware that England occupies the first position among nations as a source of mineral wealth, and to enable you to appreciate the truth of this assertion, allow me to cite a few figures published by Mr. Robert Hunt, F.R.S., the keeper of mining records at the Royal School of Mines. In 1863 the value of minerals produced was £29,151,976, from which metal of the value of £36,364,-327 was extracted. There were produced—

Tin ore	15,170 tons.
Copper ore	212,947 "
Lead ore	91,283 "
Silver ore	88 "
Zinc ore	12,941 "
Iron ore	3,500,000 "

Further, it is interesting to compare the results given by Mr. Hunt, in 1858, with the above, for we find that the mineral wealth of England has nearly doubled in five years; for in 1858 the value of the metals produced amounted only to £18,105,708. I must not omit to state that, during the last few years, England has also taken the lead in the manufacture of aluminium (Jno. Bell & Co., manufacturers, Newcastle) and magnesium, by Messrs. Mellon & Co., Salford, who have adopted the method proposed by Mr. Sonstadt. As to the four new metals which have been of late discovered, viz: cœsium, rubidium, thallium, and indium, they are as yet but scientific curiosities, but as their discovery is due to spectrum analysis, I shall refer to them more especially when treating of the method by means of which the discovery of these metals has been made, an illustration of which I shall be able to give, through the kindness of Mr. Ladd, who will show you the various spectra on the screen at the conclusion of the lecture.

Since I had the pleasure of drawing your attention last year to the then novel application of magnesium to the art of photography, owing to the intense light which that metal produces, (for it has been calculated to be equal to $\frac{1}{525}$ part of that solar light, and has been seen at a distance of 28 miles at sea, and also to its intense actinic power,) Mr. Bultinck has proposed the substitution of this metal for zinc in galvanic batteries, and states that he believes the substitution would prove a very advantageous one to electricians. The employment of this metal will be greatly facilitated by the large works which have been erected for its manufacture at Boston, in America.

Although Mr. Faraday observed many years ago that light was transmitted through thin leaves or sheets of the following metals: platinum, palladium, rhodium, gold, silver, copper, tin, lead, iron, and aluminium, still we were not prepared for the interesting results that Mr. Quincke has obtained and published in the *Philosophical Magazine* for March, 1864. That gentleman endeavored to determine directly the velocity with which light travels through metals, and he found, strange to say, that it travels faster through gold and silver than through a vacuum. Further, he adds that he was unable to detect any difference in the components of the light which had previously passed through transparent substances, such as plates of glass. The

comparative rapidity of light in passing through metals and a vacuum appears to me to be in favor of the new theory of light, which I took the liberty of expounding to you in my first lecture. Although we could conceive the passage of light through a thin film of metal, still chemists were astonished when Mr. Henry St. Claire Deville, whose name I have had the pleasure of often citing in these lectures, published, conjointly with Mr. Troost, some interesting papers on the porosity of substances under the influence of high temperatures. His experiments enabled him to show that even platinum and wrought iron tubes, the latter one-eighth of an inch thick, are, when carried to a high temperature, permeable to gases. The importance of these results cannot be overrated by chemists, when the permeability of platinum is considered, as that metal has been employed by them under the conviction that its high density and mode of manufacture destroyed all porosity. As to iron, the knowledge of that fact is most important, especially in the manufacture of coal-gas, where iron retorts are used for distilling the coal. So complete is the permeability of iron at a high temperature, that an iron tube, which had been filled with hydrogen gas before the experiment, was found to contain only a trace of it at the end of a few hours.

Considering the short space of time which I have at my command, I can only state that you will find in the Royal Society's Transactions (vol. 152, part 1, page 1) a most elaborate paper on "The Influence of Temperature on the Electrical Conducting Power of Metals," and also (vol. 150, part 1, page 85) one on the "Conductibility of Copper." These researches of Dr. Mathiessen deserve the close attention of all electric telegraph engineers.

The study of metals must convince every student that, although science has progressed in a marked manner during the last fifty years, still that there is a great deal more to do than has been done. Although we have known copper, zinc, lead, tin, and iron for many centuries, still hardly a month passes without new properties of these metals being discovered, or facts connected with the improvement of their manufacture, or the removal of the impurities they contain. I therefore deem it my duty to advert to a few papers that have been published recently respecting certain impurities which particular metals contain, which impurities, in some instances, enhance the value of the metal, and in others lower their commercial value. No class of substances teaches the young chemist the difficulties and the labors he must be prepared for, if he wishes to be what is technically termed a good operator, and if he pretends to prepare a *pure* substance. I would therefore advise all young men studying chemistry, carefully to read the labors of J. S. Stas on "The Determination of the Equivalents of Chlorine, Sulphur, Nitrogen, Silver, Potassium, Sodium, and Lead," published in the *Moniteur Scientifique* of 1861 and 1864, where they will notice that Stas has spent months of time to obtain a few ounces of *pure* silver, lead, &c.

Copper.—The same may be said of the researches of Mathiessen to obtain pure copper, for his studies above alluded to have enabled

him to state that there is no alloy of copper which conducts electricity better than pure copper, (page 92 of the above memoir,) for he found that the most minute quantities of arsenic, phosphorus, sulphur, selenium, tellurium, and oxygen diminished the conducting power of that metal. Whilst on the impurities of copper, I must not fail to mention some valuable additions which Messrs. Abel and Field have published in the *Journal* of the Chemical Society of London, on the means of determining various impurities which copper contains. Thus they found sometimes traces, and sometimes several per cent., of the following impurities in many samples of commercial copper, silver, arsenic, antimony, bismuth, lead, tin, and iron, (see tables, vol. 14, page 302,) and Mr. Abel, in a paper inserted in the same journal in 1864, proved that copper contained sulphur, as a general constituent, but only in minute quantities; selenium, as an occasional constituent; and that oxygen was always present, and sometimes in considerable proportion. Thus, in dry copper he found the quantity of oxide of copper, not as Messrs. Dick and Percy have stated, from 10·21 to 9·34 per cent., but from 3·77 to 4·56 per cent. Mr. Abel gives the following numbers as representing the average proportion of oxygen obtained with a series of samples, taken in diverse stages in the manufacture of copper:

	Oxygen per cent.
"Dry" copper	0·42
Do., (another specimen)	0·50
"Half-poled" copper	0·20
"Tough-pitch" "	0·03
"Over-poled" "	0·03

Iron.—As far as our present day's knowledge extends, no metal is more influenced than iron, either for good or for bad, by the presence in it of a minute quantity of another element. Thus, a few thousandths of carbon transform it into steel, and a few per cent. of the same element converts it into cast iron; a few thousandths of sulphur, or a few per cent. of silicium, renders iron "red-short," that is to say, brittle at a red heat, whilst the same quantity (thousandths) of phosphorus makes it "cold-short," or brittle at natural temperature. These facts explain why iron smelters and manufacturers do all in their power to use ores as free as possible from these impurities, or apply all their skill to remove them from the ores or metal when present. I am therefore satisfied that all iron smelters will appreciate the value of the following facts, published by M. Caron in the *Comptes Rendus* of the Academy of Science of 1863, on the influence of manganese, when used on the blast furnace to remove silicium from cast iron. The following table shows the relative quantity of manganese and silicium existing in the cast iron thus produced:

	Manganese.	Silicium.
No. 1	7·93	0·05
" 2	6·32	0·08
" 3	4·70	0·30
" 4	3·81	0·55
" 5	2·25	0·76
" 6	3·90	0·59 cold blast.
" 7	2·10	0·75 hot blast.

This table shows that as the quantity of manganese decreases in the pig iron, the quantity of silicium increases; further, that the higher the temperature (all the rest of the operation being conducted in the same manner) the quantity of silicium increases and the manganese decreases.

M. Caron has further made the important remark, that it is the interest of the iron smelter to use as much lime in the blast furnace as practicable, when manganiferous ores are employed; for not only does lime facilitate the introduction of manganese into the iron, but also helps in a marked degree to remove the excess of silicium.

Eight or nine years ago I made the observation that if manganese had not the property of removing phosphorus from iron, it had the one of hiding or of counteracting the bad influence of that element on iron; in fact, I found that cast iron, containing as much as one or two per cent. of phosphorus, would yield good mercantile iron if the pig-iron contained at the same time five or six per cent. of manganese, and I have lately heard that manganiferous ores have been used with great advantage by the Cleveland iron smelters to overcome the "cold shortness" of their cast iron, which is due, as is well known, to the presence of phosphorus compounds in the Cleveland iron ore.

It is highly probable that the advantages which have been derived from the employment of "spiegeleisen" iron, in improving the quality of steel produced by Bessemer's process, is owing, not only to the fact that this peculiar iron contains a large quantity of carbon, which it yields to the molten iron contained in the large crucible used in Bessemer's process, but that the manganese it contains contributes also to hide the influence of the phosphorus, or to overcome the detrimental properties which a trace of phosphorus would impart to the steel produced by this process. I say hide, because the phosphorus is still present, since that substance cannot be removed by the above process from any pig iron in which it may be present.

M. Caron has published in the *Technologiste*, for 1864, a paper, in which he shows that no amount of lime on the blast will remove phosphorus from any ore which may contain it; and that tin-plate manufacturers and others who employ charcoal iron, should pay the greatest attention to the quantity of phosphorus contained in the charcoal they employ for refining ordinary iron. Thus some charcoals are susceptible of yielding as much as 1 per cent. of phosphorus to iron, whilst others only 0·12 per cent., and lastly, some only a trace.

If phosphorus, sulphur, and silicium are injurious to the quality of iron, the metal called tungsten, on the contrary, appears to improve in a marked degree its quality, especially when in the state of steel. This fact has not only been demonstrated beyond all doubt by Mr. Mushet, but also recently by some scientific researches due to M. Caron, who has proved that steel containing tungsten presents greater tenacity, and can be used with great advantage for many purposes; in fact, he thinks that tungsten can be used instead of carbon as a converter of iron into steel. There can be no doubt that the employment of tungsten, in connexion with the hardening of steel, and other

various applications which that metal is susceptible of, will be greatly enhanced if the fact stated in the *Chemical News* of August 25th is brought to bear, viz: that a Swedish chemist has found a simple and practical method of extracting tungsten from its ore so as to reduce its cost of production to a few shillings per pound.

Mr. R. Johnson and myself have published a paper in the Memoirs of the Royal Society, in which we showed that the conductibility of iron was greatly modified by the quantity of carbon it contained, as proved by the following table:

	Found.	Conductibility of silver = 1,000.
Wrought iron	13 92	436
Steel	12 65	397
Cast iron	11·45	359

We also found that the hardening of steel had the greatest influence on its expansibility; for whilst a steel bar, hardened to the maximum, expanded to a degree which may be represented by 84, the same steel, rendered as soft as possible, expanded only 62.

Although the oxidation of iron, or its rapid destruction under the influence of the carbonic acid and the oxygen of the air, is a source of great advantage to those who manufacture this article, still, in many instances, it is a source of annoyance to those who possess articles made of that valuable metal, and in others it is a national loss, as in the rapid decay which our iron ships of war undergo. Allow me, therefore, to say a few words on these points.

It is easy to preserve small articles made of iron from rust, either by plunging them into a weak solution of caustic alkali, (whether the iron is preserved by a peculiar action of the alkali, or because it prevents the action of the carbonic acid of the atmosphere in conjunction with oxygen and moisture, are points to be determined,) or covering them with a varnish made of india rubber, gutta-percha, and a small amount of fatty matter. As to the preservation of ships' bottoms from corrosion, without entering here into the various methods that have been proposed of late to effect this important object, still I deem it my duty to call your attention to one or two methods that have been tried with apparent success. Thus Mr. Leach has applied on the iron surface of ships' bottoms a coating of gutta-percha or other cement, and fastening by it sheets of glass of about one-fourth of an inch in thickness. The glass is previously bent to the shape of the ship, and pierced for the reception of the screw or bolts, which are preserved from immediate contact with the metal bolts by coating them with a little of the fastening mixture.

M. Becquerel relates, in the *Comptes Rendus* of the Academy of Sciences, 1864, the results which he obtained by the application of his galvano-electric process on the iron keels of some of the French men-of-war. This process is based on the same principles as those adopted by Sir Humphrey Davy, in 1824, for preventing copper sheathing from being rapidly corroded by sea-water, and which consisted, as you are aware, in attaching at various distances blades of zinc between the

wooden side of the vessel and the copper sheets, or, what effected the same purpose, in using brass nails for fastening the copper to the sides of the vessel.

M. Becquerel employs zinc in connexion with iron, thus establishing a galvanic current which renders the iron, like the copper in Sir. H. Davy's experiment, electro-negative, or possessing the same kind of electricity as oxygen; therefore communicating to it the property of liberating oxygen from any compound, instead of absorbing or fixing it. M. Becquerel has proved that the galvanic action of the zinc on the iron exercises its influence on the whole of the iron surface of the ship, but nevertheless that its influence decreases as the square of the distance, and consequently that its action is only sufficiently powerful to preserve iron from corrosion for a limited distance, and consequently the preserving bands of zinc must be placed at short intervals from each other.

Mr. Johnson and myself published, as I hope you will remember, in the *Journal* of the Society, two or three years since, two papers bearing upon this same subject, the first paper containing facts exactly identical with those published in 1864 by Becquerel; the second showing the advantage that would be derived by ship-builders in using galvanized iron plates, instead of wrought iron ones, for plating our men-of-war, for you are aware that the attack of sea-water on iron plates in contact with oak was very great, being 2·880 as compared with galvanized iron, which was only of 0·095, all the circumstances of action being equal in both cases.

But the most important result that Mr. Johnson and I have arrived at on this point, is the demonstration, in a paper we have published, on "The Action of Sea-water on certain Metals and Alloys," that the action of sea-water on lead is nearly *nil*, as seen by the following table:

Action of Sea-water upon Metals.

1 Metre.	Grammes.
Steel	29·16
Iron	27·37
Copper (best selected)	12·96
Do. (rough cake)	13·85
Zinc	5·66
Galvanized iron (Johnson's process)	1·12
Block tin	1·45
Stream tin	1·45
Lead (virgin)	trace.
Lead (common)	trace.

This metal can, therefore, be used with great advantage to preserve the keels of iron ships from being corroded by the action of sea-water, and that the objection which might be raised as to its softness might be easily overcome by adding to lead a few hundredths of either arsenic or antimony, which would increase its hardness, and thus render it better fitted for the purpose referred to. From experiments that we have made we can further state that, in our opinion, Muntz's metal is a far superior article to copper for sheathing ships. (See *Society of Arts' Journal,* April 21, 1865.)

As a few ladies have done me the honor to attend these lectures, it may be interesting to them to have a simple method of cleaning silver, or silver-plate, without the trouble of employing rouge or other cleaning powder, which, besides rapidly wearing off the metal, takes up much of their servant's time. It consists in plunging for half an hour the silver article into a solution made of 1 gallon of water, 1 lb. hyposulphide of soda, 8 ozs. muriate of ammonia, 4 ozs. liquid ammonia, and 4 ozs. cyanide of potassium; but as the latter substance is poisonous, it can be dispensed with if necessary. The plate being taken out of the solution, is washed and rubbed with a wash leather.

Improvements have also been made of late in coating cheap metals, such as iron and brass, with more valuable ones, so as to enhance the value of the fancy articles made with them. If you remember, I referred to a process devised by Mr. Oudry for coating cast iron with copper or bronze. The method that I wish now to bring before your notice is one devised by Mr. Weil, and is based on the same principle as the one which has been in practice for some time in tinning iron pins, or covering brass with gold, viz: plunging the article to be coated into a boiling alkaline solution of a salt of tin, or a salt of gold, and, in the case of Mr. Weil, into one of copper, which consists of an organic salt of copper, (say the double tartrate of copper and potash,) with an excess of alkali, taking care that the cast or wrought iron to be coated is in contact with a brass wire during the operation.

I shall now take the liberty of dwelling for a short time on various memoirs which have been published in connexion with the physical properties and chemical composition of alloys.

You will find in the "Transactions of the Royal Society," vol. 150, some extensive researches by Dr. Mathiessen on "The Electrical Conducting Power of Alloys;" also in vol. 154, on the influence which heat exercises on that important physical property of alloys. Mr. Johnson and myself have published papers on the density of alloys, as well as on the hardness, expansion, and conductibility of the same. It was admitted, some years ago, that alloys were simply a mechanical mixture of various metals, but the systematic researches which we have published leave no doubt that when certain metals, such as tin and copper, bismuth and lead, zinc and copper, are employed in equivalent quantities, and that the proportion of each metal does not exceed two or three equivalents of one, to one equivalent of the other, that they are susceptible of combining and forming definite compounds. I may state, in corroboration of this statement, that if one equivalent of zinc and one equivalent of copper are melted together, or 49·32 of copper and 50·68 of zinc, and well stirred, and allowed to cool until a crust is formed on the surface, and then a hole be made in the crust, and the fluid portion poured out, well-defined prismatic crystals, sometimes of ½-inch long, will be found to coat the interior of the solidified mass, whilst if 45 per cent. of copper and 55 per cent. of zinc, that is to say, proportions which are no longer equivalent to each other, then, instead of obtaining a fine golden colored crystalline alloy, a white amorphous mass will be produced; in fact, no brass founder attempts

to use more than 40 per cent. of copper to produce brass, for experience has taught him that if he exceeds that quantity, he obtains such a white metal that it is no more a marketable article. Another example is furnished by certain alloys for bronze. Thus, when two equivalents of tin for one equivalent of copper are employed, the conductibility of this alloy for heat is equal to that of both the metals together entering into its composition, whilst if the conductibility of alloys, composed of three equivalents of copper to one equivalent of tin, or four equivalents of copper to one equivalent of tin, is ascertained, it will be found that their conductibility is quite different and independent of that of the metals entering into their composition; in fact, the conductibility of four equivalents of copper and one equivalent of tin is five times less than the one first cited.

Without occupying your time with further instances, let me call your attention to an important fact that Dr. Mathiessen, Mr. Johnson, and myself have observed, viz: that the addition of a small quantity of a metal, which may be considered as an impurity, completely modifies, in many instances, its properties, and the most important example that I am acquainted with, is the influence which the addition of one or two per cent. of iron exercises on the properties of brass. If a brass be composed of 60 per cent. of copper and 40 per cent. of zinc, it will be susceptible of being drawn or bent when cold, but cannot be forged or worked when heated, whilst if 1·75 or 2·0 per cent. of iron be substituted for the same quantity of zinc, then a most valuable brass is obtained, for not only is this brass capable of being forged at a red heat like iron, but its tenacity is increased in an enormous proportion, for each square inch of surface is able to support a "breaking weight" of from 27 to 28 tons, a tenacity nearly equal to that of iron.

Messrs. Beyer & Peacock of Manchester, who experimented with bolts made of this alloy, in the hope of substituting them for iron ones in the fire-boxes of locomotives, found that these bolts would support a strain equal to those of iron, and that the threads of the screw were not stripped with more facility than those of iron when exposed to the same strain.

There is no doubt that when this alloy becomes more generally known, many valuable applications of it will be made in the arts and manufactures.

Whilst dwelling on valuable brass alloys, let me state that two alloys have lately been introduced which will prove useful to those requiring them, namely, a white alloy, which is chiefly employed for the bearings of the driving wheels of locomotives, owing to its extreme hardness, and which is composed of—

Zinc	77
Tin	17
Copper	6
	100

The other alloy has been lately proposed to calico printers by Mr.

Lenssen as a substitute for the steel blades used by them to remove the excess of color which adheres to the surface of their printing-rollers, and which blades bear the name of "doctors."

Mr. Lenssen's metal is composed of—

Tin	4·93
Zinc	9·78
Copper	85·29
	100·00

This alloy is stated to have all the flexibility, tenacity, and hardness required for the "doctors" used in calico printing; and further, it presents the great advantage of not being acted upon by acid liquors, which action is often a great source of annoyance to calico printers.

I shall conclude this lecture by alluding to the extraordinary modification in the fusibility of metals when several are fused together. Thus, for example, the following well-known alloys, which liquify in boiling water:

	Newton's alloy, fusible at 212°.	D'Arcet's alloy, fusible at 201°.
Bismuth	5	8
Tin	3	3
Lead	2	5

Whilst the fusing point of these metals, when taken separately, is as follows:

Bismuth	513°
Tin	451°
Lead	620°

Therefore the fusing point of each metal is several hundred times higher than when they are mixed in the above proportions.

A still more fusible alloy has lately been brought before the notice of the public by a Mr. Wood, in one of the American journals, in which he states that by melting together

Lead	8 parts.
Bismuth	5 "
Tin	4 "
Cadmium	3 "

An alloy is obtained whose point of fusion is equal to 140 degrees; therefore susceptible of being used with great advantage for dental purposes.

I have now to refer to the four metals which have recently been discovered, viz: cœsium, from *cœsius*, "sky-colored," owing to two blue lines which it produces in the spectrum; rubidium, from *rubidus*, "dark-red," owing to the existence in its spectrum of two red lines of remarkably low refrangibility; thallium, discovered by Mr. William Crookes, and which derives its name from *thallos*, "a budding twig," symbolizing the beautiful green tint of budding vegetation; indium, discovered by Messrs. Reich & Richter of Freiburg; all of which are due to the introduction into science of a mode of investigation known as the "spectrum analysis."

The principle upon which this mode of research is based has been of late so well described and illustrated by Dr. Wm. Allen Miller, in a paper read before the Pharmaceutical Society, (see Society's *Journal*, February, 1862,) and by Professor Roscoe in four lectures at the Royal Institution, London, (see *Chemical News*, vols. 5 and 9,) and which lectures have received such a wide publication that I think it useless here to enter into details, and more especially as Mr. Ladd will illustrate, by means of his powerful electric lamp, the spectra of some of the above metals, as well as those of potassium, strontium, barium, &c.

Locks and Keys.

From the London Journal of the Society of Arts, No. 708.

At a recent meeting of the Institution of Mechanical Engineers, a description of a new construction of lock and key was communicated by Mr. J. B. Fenby, of Birmingham. The writer pointed out that in all previous locks there had been two important defects in principle, which are fatal to their security—the first being that, although access to the works of the lock is greatly impeded by the many ingenious contrivances, they still admit of the works being got at through the key-hole, and thus allow of a series of attempts being made to pick the lock; while the second defect is the possibility afforded for repeating the trial of a false key, and thus perfecting it by successive alterations after trial. In the new lock described in the paper, which is the invention of the writer, the principle is adopted of dividing the key into two parts, the bit or portion by which the levers of the lock are raised being separate from the stem or handle of the key. For unlocking the lock the bit is inserted through a second key-hole into a radial slot contained in a solid rotating cylinder, the cylinder being then turned round by the stem of the key acting in the centre key-hole; the bit while being carried round is also pushed outwards along the radial slot by means of a cam, and is thus made to protrude from the circumference of the cylinder sufficiently to act upon the levers of the lock, and thereby set the bolt at liberty to be withdrawn. The bit is then pushed out of the radial slot, and drops into a receptacle inside the door; and the further revolution of the cylinder withdraws the bolt, and unlocks the door. The consequence of this mode of construction is that, as soon as the bit has been inserted in the lock and the cylinder turned round for unlocking, the radial slot in the cylinder is carried away from the key-hole, which is completely closed by the solid cylinder, whereby all access to the interior of the lock through this opening is effectually prevented, nor can anything be passed into the lock in this way except a detached bit of metal not larger than the bit by which the lock is opened. The centre key-hole, into which the stem of the key is inserted for turning the cylinder is simply a blind socket with parallel sides, and without any communication with the interior of the lock. The only possibility of opening the lock by fraudulent means lies, therefore, in the use of a counterfeit bit intro-

duced into the lock in place of the true bit; but this counterfeit is absolutely lost to the operator and retained inside the safe at the very first trial, so that he is not only limited to a single attempt, but from the attempt itself no clue whatever is obtained as to the nature of the defect in the counterfeit. In consequence of the levers not being accessible for feeling through the key-hole, and, therefore, not requiring to be all shaped to the same average curve at the portion acted upon by the key, each lever can be shaped to its own proper curve, and the play in the action of the levers is thus reduced to a minimum; hence a much slighter amount of error in the counterfeit than is admissible in the case of previous locks will prevent its opening this lock. The importance of these advantages in the principle of the new lock is illustrated by the celebrated bullion robbery of the South-eastern Railway some years ago, which attracted special attention from the remarkable skill with which it was accomplished and the large value of the property stolen; but even in this case success was not attained until as many as seven trials had been made with the same false key, the latter being altered after each trial according to the indications obtained from the trial, until it was at last sufficiently perfected to be capable of opening the lock of the bullion safe. In that instance also the successive trials were made without leaving any indication behind that the lock had been fraudulently attempted, although it was fitted with detector contrivances for this special purpose; but in the present lock the false bit, being retained inside the safe, is found when next the safe is opened, and furnishes proof of the fraudulent attempt having been made, as well as showing how near the counterfeit key has approached to the original. The locks are made with six levers, and the corresponding steps in the bit are cut with the greatest accuracy by a machine specially contrived by the writer for the purpose, with a permutating arrangement, having an extent of permutation admitting to each lock differing from every other lock made. For locking the lock, the stem only of the key is required, as the bolt is shot simply by turning the cylinder; and as the key-hole for the stem is made with a notch cut out on one side only, while the cylinder is not permitted to make a complete revolution, the key-stem cannot be taken out of the lock whilst it remains unlocked. This lock has an important advantage in simplicity as well as solidity of construction, as there are no more than sixteen separate pieces altogether in the complete lock. Moreover, as both key-holes are simply blind holes with parallel sides, having no communication with the interior of the lock, they do not admit of injury to the lock by the explosion of gunpowder. Specimens were exhibited of the new lock, the action of which was shown both with the true key and with counterfeit keys; and it was shown by trial that the counterfeit failed to open the lock, notwithstanding that, by means of the permutating cutting machine, it had made a much nearer approach to a perfect copy than was practicable in the best hand-work from a wax impression. The key-cutting machine for cutting the bits was also exhibited, having been lent for the purpose by Messrs. Whitfield, of Birmingham, the makers of the lock.

Photographing Cannon Balls.

From the London British Journal of Photography, No. 323.

Some few months ago, when on a visit to Woolwich Arsenal, we were shown by Mr. M'Kinlay, Proof Master, some photographs taken of guns while being fired, which not unnaturally excited feelings of surprise. So rapid had been the exposure, and so well had the proper moment for the exposure been seized, that the projectile could be seen protruding from the cannon's mouth while in the act of proceeding on its distant mission. Mr. M'Kinlay kindly afforded us every requisite information relative to his invention for securing such wonderful results; and, from the fact that the comparative efficiency of certain kinds of small arms and the influence they are now exercising in European affairs are at present receiving a large share of public attention, we think that it may not prove uninteresting to bring before our readers some matters of scientific interest in connexion with our own "great guns," and the means employed for ascertaining by photography, and with the utmost possible precision, not only the path of a projectile in the air, but the time occupied in its progress between two or more points anywhere in the course of its flight.

It will be obvious that, when it is desired to obtain a photograph of a gun at the moment of discharge, the gun itself must be made subservient to the exposing and covering of the sensitive plate. It is impossible that any person, however delicate his eyes and ears may be, can operate so dexterously as to stop the exposure when the ball has been projected, say a few inches from the muzzle of the gun, and when it is, consequently, traveling at its greatest velocity. This can only be accomplished by automatic arrangements, aided by electricity.

Let us now suppose that a stereoscopic camera, fitted with powerful lenses of short focus, has a thin light disk fitted up in front of the lenses, revolving on an axis between the two lenses. Two holes in this disk correspond with the apertures of the lenses, so that if a circular spring—like that of a pair of snuffers—cause the disk to make half a revolution with great rapidity, the holes or apertures will, when flashing past the apertures of the lenses, admit the light for an exceedingly brief period of time. This is the means employed in the Arsenal for effecting the exposure of the plate.

We shall now enter into the details of the manner of discharging and arresting the circular exposing diaphragm. The opening and shutting of the camera at the precise instant of time is, as we have said, by far too nice an operation to be accomplished by hand. It must be borne in mind that a gun commences to recoil as soon as the projectile is fairly clear of its muzzle. The picture which we examined had been taken while the projectile was yet emerging from the gun's mouth, and before it had got quite clear of it, and consequently before the recoil of the gun had commenced. The exposure was very rapid, but not so much as to show the front edge of the emerging projectile, with a sharp outline. Although the gun, from the recoil not having

commenced, was quite sharp, the front edge of the projectile was, so to speak, vignetted.

The gun is fired by means of the galvanic tube invented by Mr. M'Kinlay, and such as is used in proving ordnance. Inside of this there is a small platinum wire, which, when a current of electricity is passed through it, instantly becomes red-hot and melts. Let us now see how this affects the operation of photographing the gun. When the gun is ready for firing, the disk in front of the lenses is wound up, so that the rotating force of the spring in the centre is at its maximum. It is retained in this position by means of a catch and trigger, (which we shall presently describe,) the latter of which is operated on by means of an electro-magnet. The following, then, is what takes place: When the galvanic current is sent through the wire, the fine platinum wire imbedded among the gunpowder of the discharging tube or fuse immediately becomes red-hot and melts. But while in process of melting it accomplishes two things—it transmits a current through it by which the electro-magnet becomes vivified and pulls the discharging trigger of the disk in front of the camera lenses; and, secondly, it ignites the gunpowder and discharges the gun. But were this all, the exposure would be made before the powder had time to ignite and consequently discharge the gun; hence it is important that the lenses be kept open until the gun really discharges its contents. The means for effecting this are as simple as they are ingenious and complete. When the trigger acts so as to release the disk from its enforced pent-up condition, it is propelled forward by the central spring until the apertures in the disk and those of the lenses coincide, where, by means of a stop, the disk is retained until the powder is ignited and the gun discharged, when, the platina wire being ruptured, the passage of the electricity is stopped, the electro-magnet simultaneously losing the power by which it was enabled to arrest the rotary progress of the disk, which thus darts forward and closes up the camera as the contents of the gun are in the act of being ejected from it.

Latest Discovery in Electricity.

From the Practical Mechanic's Journal, June, 1866.

In the course of some experiments with a magneto-electric machine of rather peculiar construction, it has been discovered by Mr. Wilde that if the induced current from the armature were made to pass through the coils of an electro-magnet, the magnet attained more than four times the lifting power of the permanent magnet from which the force was at first obtained, and, as it would appear, *prima facie* in opposition to the laws of conservation of energy. Mr. Wilde has thus expressed himself: "Having discovered the fact that a large amount of magnetism can be developed in an electro-magnet by means of a permanent magnet of much smaller power, and as definite quantities of magnetism are accompanied by the evolution of proportionate quantities of dynamic electricity, and since an electro-magnet, when ex-

cited by means of a voltaic battery, possesses all the properties of a permanent magnet, it appeared reasonable to suppose that a large electro-magnet, excited by means of a small electro-magnetic machine, could, by suitable arrangements, be made instrumental in evolving a proportionately large quantity of dynamic electricity, notwithstanding the pulsatory character of the electricity transmitted through the wires surrounding the magnet." The accompanying figures will afford a tolerably clear idea of the apparatus Mr. Wilde employed at the beginning of his experiments. The cylinder C C has a truly bored hole, A, in its centre. The cylinder is composed of two slabs of cast iron, C C, which are separated from each other by bars or strips, B B. Screws are inserted through the slabs and strips by which these are held together. A number of permanent magnets, one of which is represented by D D, are placed over the cylinder, and these magnets are formed so as to grip the cylinder tightly, thereby making good contact. The iron sides, under these conditions, become the poles of a powerful magnet, which are increased in power as one magnet after another is added. Within the hole A, Fig. 1, an armature is made to rotate. This armature is shown in section and elevation at Figs. 2 and 3. In the armature two deep grooves are cut, and wire is wound longitudinally over it, as at M N, Fig. 3. From the construction it will be evident that, as the armature is made to rapidly revolve in the hole A, its magnetism will be reversed twice in each revolution, and its surrounding wire will give off electrical currents as with an electro-magnetic machine of the usual form. The armature was driven at the rate of 3000 (or thereabouts) revolutions per minute by means of a small steam engine. At this velocity 6000 waves of electricity would be given off, each alternating in opposite directions. Where a commutator, however, is attached to the machine, the currents would then be all sent in one direction. In one of the earliest experiments with this apparatus the wires of the armature were connected with a tangent galvanometer, to measure the amount of electricity evolved. One magnet, weighing about one pound, was first placed on the cylinder, and three other magnets of the same size were added in succession. It was found that the amount of electricity given off was directly proportional to the number of magnets on the cylinder. When the electricity obtained from one of these four permanent magnets was made to pass through the coils of an electro-magnet, the latter lifted nearly four times the weight of the former. This induced Mr. Wilde to make a second cyl-

FIG 1.

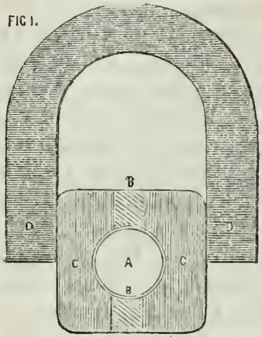
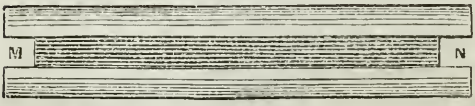


FIG 2

Fig. 3.



inder, and place it in contact with electro-magnets excited by the first machine, a very powerful current being the result. Lastly, he added a third machine, with a cylinder of 10 inches internal diameter, and when the three pieces of apparatus were connected together, and the armatures made to revolve, quantities of electricity far exceeding that obtainable by any other means hitherto used were given off. The illuminating power of the current thus obtained was of the most splendid description. Two carbon electrodes, half an inch square, were placed in the holders of the electric lamp, and a parabolic reflector was fixed so that the rays should diverge at a considerable angle. With this arrangement placed on the top of a lofty building, "the light evolved from it was sufficient to cast shadows from the flames of the street-lamp a quarter of a mile distant upon the neighboring walls." When viewed from that distance the light was a magnificent object to behold, having all the rich effulgence of sunshine. The calorific power of the current was so great that it melted pieces of cylindrical iron rod, 15 inches long, and ¼ inch diameter. It melted 15 inches of No. 11 copper wire 0·125 of an inch thick, and with another arrangement of the armatures melted 7 feet of No. 16 iron wire 0·065 of an inch in diameter, and made 21 feet of the same wire red-hot. The most remarkable fact of all is that the primary permanent magnets weigh only one pound each, and the current they give is insufficient to melt the shortest piece of iron wire, yet, by the intervention of electro-magnets as described, a current of extraordinary power is produced. The third machine made, which was the largest, had a cylinder with a 10-inch bore. The whole machine is only 80 inches in length, 24 inches wide, 60 inches high, and weighs 4¼ tons. The smaller cylinders of the other machines were 2½ inches in diameter. The whole of them, therefore, occupy very little space, and although they are heavy the only moving portions of them are the armatures. The invention, therefore, seems likely to be of special value for light-house illumination, and for other purposes which as yet it is impossible to foresee. This *most important* discovery of Mr. Wilde was brought before the Royal Society, at a recent meeting, by the distinguished Michael Faraday.

Safety Gunpaper.

From the London Mechanics' Magazine, April, 1866.

The inventive genius of man is as constantly developing itself in the direction of munitions of war as it is in that of implements of peace. As we are called upon from time to time to record some vast stride in the improvement of machinery the object of which is peace and the conservation of human life, so have we occasionally to chronicle the advent of some weapon or material the mission of which is war and destruction. We have gunpowder, gun-cotton, gun-saw-dust, and now we add to this category a new material—gunpaper. Now, however lightly we may esteem the lives of those against whom we are to try the force of these various explosive compounds, we are apt to have a

somewhat higher regard for our own. Hence the object has always been to obtain a material embodying a maximum explosive power, and which, at the same time, shall carry with it a minimum of danger to the user. In gun-cotton we obtain the first-named element in a marked degree, but unfortunately not the last, and this has led to the Austrians recently clearing out their stores of gun-cotton and returning to their old love—gunpowder. This fact of insecurity to life being the inherent condition of all explosive compounds has been the basis of attempts to render them explosive and non-explosive at will, and the attempts have succeeded; but success has been purchased at too great an expense—the portability of a given mass of gunpowder is vastly decreased, and its usefulness on an emergency sadly impaired. So, from one cause or other, the powder-protecting schemes have passed away to that land which is constantly receiving fresh accessions of useless ingenuities. But besides exercising itself in rendering existing explosive compounds safe to handle and transport, ingenuity has been endeavoring to achieve a far better result. It has striven to produce a material which, with all the elements of destruction in its nature, should yet embody the much desired principle of safety. And, in these respects, the safety gunpaper, as now presented to us, certainly appears to succeed in a marked degree. It combines highly penetrative power with a safety which, if not absolute, is, at any rate, far superior to that of either gun-cotton or gunpowder.

This gunpaper is the introductien of Mr. G. S. Melland, of 38 Lime Street, London, who is well known as having been the means of introducing many new things in fire-arms, the Snider breech-loader and the Jocelyn rifle amongst others. It consists of paper impregnated with a composition formed of the following ingredients: Chlorate of potash, 9 parts; nitrate of potash, $4\frac{1}{2}$ parts; prussiate of potash, $3\frac{1}{4}$ parts; powdered charcoal, $3\frac{1}{4}$ parts; starch, $\frac{1}{21}$ part; chromate of potash, $\frac{1}{15}$ part; and water, 79 parts. These materials are mixed together and subjected to an hour's boiling; the solution is then ready for use, and the paper is passed in sheets through the mixture. The saturated paper is now ready for manufacturing into the form of a cartridge, and is rolled into compact lengths of any diameter, from that of a small revolver to that of a 600-pounder. These rolls may be made of the exact length required for each charge, or they may be made a foot, or even a yard long, and be afterwards cut up to suit the charge. After rolling, the gunpaper is dried at a temperature of 212° Fahr., when it presents the appearance of a compact grayish mass, resembling nothing so much as a piece of vulcanized india rubber door spring. Some comparative experiments we have recently made with this material lead us to the conclusion that the advantages claimed for it over gunpowder are by no means imaginary or slight. It appears to afford a perfect substitute for gunpowder, superseding gun-cotton and all other explosive compounds yet tried. It is safe alike in manufacture and in use; the chemical solution is the reverse of combustible, and the paper is dried at a very low temperature. In use its manipulation is unattended by the danger

attaching to gun-cotton, it may be freely handled without fear of explosion, which is not even induced by percussive action. It is, in fact, only exploded by contact with fire or at equivalent temperatures, and is readily and accurately cut into cartridges by hand. In its action it is quick and powerful, having, in this respect, a decided advantage over gunpowder, than which it is also much cleaner in action. Its use is unaccompanied by the greasy residuum always observable in gun-barrels fired with powder, the barrels, after firing the gunpaper, being perfectly dry and comparatively clean. Its explosion produces less smoke than that of gunpowder, and it was only occasionally that we observed it to leave a slight deposit behind, and that was of a dry nature, and might, we think, be obviated by improved details of manufacture. It has less recoil, with quicker penetrative power than gunpowder, and is stated to be less liable to deterioration from damp than the latter material. It is readily protected from all chance of damp by a solution of xyloidin in acetic acid. The xyloidin is prepared by acting on paper with nitric acid, one part thereof being dissolved in three parts of acetic acid of specific gravity of 1·040.

Its advantages are substantiated by the results of the experiments to which we have alluded, in which the weapon used was one of Mr. Melland's improved revolvers. Six rounds were first fired with cartridges containing 15 grains of gunpowder and a conical bullet at 15 yards range, which gave as a result an average of $1\frac{3}{16}$ inch penetration into deal. Six rounds were next fired with 10 grains of gunpaper and a conical bullet at the same range, the result being an average penetration of $1\frac{3}{8}$ inch into deal. This shows the superior penetrative power of gunpaper to be $\frac{3}{16}$ inch over that of gunpowder at equal ranges, but with 33 per cent. less material. Six rounds were then fired with an increased charge of 15 grains of gunpaper and a conical bullet, at the same range, and at each shot the bullet passed through a 3-inch deal. But this does not represent the ultimate power of the gunpaper, as even at 29 yards range 12 grains of the paper fired from a pistol of 54 gauge (·44-inch) sent a heavier bullet through a 3-inch deal. The power of the safety gunpaper was thus proved to be far greater than that of gunpowder; how much more matters not for our present purpose. In a Snider breech-loader, charges of 2 drachms of gunpaper with a conical bullet were fired from a capsule with central fire and metal base, with equally good results, and with a comparatively slight recoil. In order to test whether the use of the safety gunpaper produced any corroding action upon the metal of the bore, we preserved a fouled revolver, and after four days we could not detect any symptoms of corrosion, or any other sign of deterioration whatever. We must not pass by one special advantage, which it occurs to us the safety gunpaper presents as applied to breech-loaders. About 25 per cent. is saved by gunpaper as against gunpowder in the length of the cartridge, and this shortening, of course, admits of a corresponding reduction in the length of the breech, thereby adding to the strength of the piece at this point, and diminishing its weight. With regard to the commercial bearing of the question, which is al-

ways an important point, we have not yet sufficient data to form an opinion. We, however, have Mr. Melland's authority for stating that, taking into account the smaller quantity required to give an equal effect, the cost of the safety gunpaper will be from 30 to 50 per cent. less than that of gunpowder. From what has already been stated, the relative merits of gunpaper and gunpowder will be clearly seen, and a very strong *prima facie* case is made out in favor of the former. It remains for time and extended application to bring out any latent defects it may possibly possess, and which could not be expected to manifest themselves at our limited trial. We trust Mr. Melland's enterprise in introducing the safety gunpaper may meet with the success it merits. As far as our knowledge of the new material and its capabilities extends, we have no reason to fear that the ultimate results will prove otherwise than satisfactory.

Pyrotechnic Experiments.

From the London Chemical News, No. 337.

On looking over a number of receipts, collected among my earlier days of chemical experimenting, I came upon a number of original receipts for colored stars, for rockets, Roman candles, and shells, which, as they were the result of many experiments, I can confidently recommend as very brilliant in color and good, and I venture to hope that not only amateurs, but even some professional pyrotechnists, may find the receipts serviceable, for even in professional exhibitions some of the colors are often sadly wanting in brilliancy.

The ingredients for each of these stars for rocket-heads, &c., is powdered separately, and then the whole is made up into a thick paste with water, which is rolled out to the proper thickness and punched into square stars and carefully dried till quite hard.

1. *Red Stars.*—Dried nitrate strontia, 4; chlorate potash, 2; sulphur, 2; black sulphide antimony, 1.

2. *Green Stars.*—Nitrate baryta, 5; chlorate potash, 2; sulphur, 2; black SbS_2, 1.

3. *Lilac Stars.*—Chlorate potash, 49; sulphur, 25; chalk, 20; black CuO, 6.

4. *Purple or Blue Stars.*—Chlorate potash, 42; pure nitrate potash, 22; sulphur, 22; CuO, 10.

With regard to the remaining receipts, I am not able to state whether they are original or not at this distance of time; still, as they are all well proved, I venture to send them, if they will not take up too much room in your journal:

5. *White Stars.*—Saltpetre, 16; sulphur, 4; black sulphide antimony, 5.

Blasting powder at 6*d.* per pound, reduced to powder, is meant in the following receipts:

6. *Tailed Stars.*—Blasting powder, 8; sulphur, 8; saltpetre, 8; coarse charcoal, 8.

Charge for two-ounce rockets.—Blasting powder, 20; charcoal, 6; saltpetre, 4. A moderate amount of blasting powder for the head to light and disguise the stars.

Composition for Roman candles between the stars lying on powder at 1*s*. 3*d*. per pound.—Saltpetre, 5; blast powder, 1½; sulphur, 1; sand, 1.

Spur Fire.—Saltpetre, 4½; sulphur, 2; finely powdered and mixed, and then gently rubbed with lamp-black, 1½; pack in cases 6 inches long and ¾ inch internal diameter.

So far for the receipts.

Having had occasion to speak of baryta and strontia, I may as well take this opportunity for mentioning a fact the discovery of which, some years ago, interested me much, and may prove interesting to such of your readers as are mineralogists, and know Clifton from its beautiful suspension bridge or otherwise. Geological books state that sulphate of baryta exists in our Clifton rocks. After much trouble in my early days I found it in the form of red veins traversing the limestone cliffs. No other sulphate of baryta, I believe, was known in the neighborhood. Sulphate of strontia, I believe, was not known to be found nearer than Aust-passage, until a quantity was found at Pylehill railway cutting, Bristol, a few years ago, and I once found some crystals at Clevedon, twelve miles distant, in the sea-cliffs. But during the last few years a number of fields running directly eastwards from the Clifton downs towards Cotham, and familiar from childhood, have been disturbed, the grass has been taken up, and numberless buildings erected. This has disclosed, lying horizontally over the upturned limestone strata forming the Clifton rocks and downs, a layer of new red sandstone of pale-yellow color. This layer abounds in masses of white pulverulent sulphate of baryta and fine crystals of sulphate of strontia. E. A. H.

On the Combustion of Gas for Economic Purposes. By Dr. Letheby.

(A Lecture delivered before the British Association of Gas Managers.)

From the London Chemical News, No. 341.

At the close of the last lecture which I had the honor of delivering to this Association at the meeting in Birmingham, I referred very briefly to the general phenomena of gaseous combustion, and to the principles of the economic use of coal-gas. It was my intention, indeed, to have entered fully into this matter; but so much time was occupied in the examination of the chemical and physical properties of the most important constituents of coal-gas, that little was left for the consideration of this part of our subject. I have, therefore, been requested to make it the especial subject-matter of this evening's lecture; and, in order that you may follow me through the various details of the inquiry, it will be necessary to pursue it from the beginning.

The phenomena of visible combustion are always the results of ener-

getic chemical action; and the heat and light which characterize it are the consequences of the violent collisions and rapid trembling of the combining atoms. When this collision occurs by the showering down, as it were, of gaseous atoms upon a solid, as you here see in the combustion of carbon and of iron in oxygen gas, and of antimony in chlorine, there may be a very intense ignition of the solid, but there is no flame. On the other hand, when the conflict is entirely among the particles of gaseous or vaporous matter, or matter in a finely divided and mobile condition, the phenomena are altogether different; for although, as before, the atoms or molecules of the burning body are intensely heated, yet from their mobility they give rise to that appearance called flame.

In all cases, therefore, we must regard flame as gaseous, or vaporous, or very finely divided matter intensely heated. That the particles of the gas or vapor must be themselves bodily and intensely heated to produce flame is evident from this—that when I burn hydrogen, or coal-gas, or the vapor of ether, or alcohol by means of a finely divided solid, as I do here with a rosette of fine platinum wire, you see how the fire glows; but there is no flame, for the combustion is limited to the thin layer of gaseous matter which immediately surrounds the metal, and the temperature of the combustion is comparatively low. But if I raise it to a higher temperature, as will sometimes happen of itself, then the whole mass of escaping gas or vapor is thrown into a state of ignition, and it bursts into flame.

Let us pause for awhile to study the complicated nature of this phenomenon. Whenever a gas or vapor burns in an atmosphere of another gas or vapor, as we here see in the flame of the burning gas and candle, the phenomena are very complicated. At the points of contact which are now at the outside of the flame, the collision of the particles, because of their rapid chemical union, is most violent; and here, therefore, we have the highest temperature; but as a portion of the outer atmosphere penetrates for some distance into the burning gas, it extends the conflict into the body of the flame, and there finding itself in the presence of complex particles, it closes with those whose energies are most active. In this manner the hydrogen of the hydro-carbon is burnt first, and the liberated carbon, standing for awhile in an ignited state, forms the luminous shell of the flame; and within, waiting for the presence of air, or rather passing out to take part in the conflict, is the unchanged gas or vapor. Every common flame, therefore, consists of at least three parts: The inner layer of unchanged gas or vapor, next the shell or cone of luminous matter, and, lastly, the outer shell of perfect combustion. That there is always an inner portion of gas or combustible vapor in every common flame may be proved by drawing it out with a glass tube and burning it at the end. See how I do it here with the flame of burning ether, and the same may be done with all other flames.

And now we are prepared to ask why it is that different substances burn with such different degrees of luminosity. The answer is clearly to be found in the circumstance that different substances contain, or

evolve, or produce different amounts of solid particles. In all these flames of hydrogen, and sulphur, and carbonic oxide there are no solid particles to be heated; but in this gas, and candle, and paraffin lamp the particles of soot or carbon are very numerous, and if it so happens that the products of the combustion are also solid particles, the intensity of the light is so much the greater. Look at the splendid combustion of phosphorus in oxygen, and of magnesium in air. In both cases you will notice that the products are a white powder, every particle of which at the moment of its formation is intensely heated. It follows from this that every circumstance which increases the number of solid particles, within a reasonable limit, or which prolongs the time of their ignition, or which exalts the temperature of it, increases the light of the flame, and, conversely, everything which destroys the particles or lowers their temperature will also destroy the light.

If I throw the solid particles of lime into this almost invisible flame of oxygen and hydrogen, you will notice how vividly I bring out the light; and so, also, if I give the vapor of a hydro-carbon, as benzole, which is rich in carbon, to the hydrogen by merely passing it through a tube packed with tow, and moistened with naphtha, you observe how brightly the hydrogen burns. In the same way we can increase the illuminating power of coal-gas by passing it into a chamber containing naphtha; and experiment shows that with common 13-candle gas the illuminating power is increased about 4·5 per cent. by every grain of naphtha to the cubic foot.

On the other hand, if I destroy the solid particles by hastening their combustion, the light of the flame is diminished. Here, with a common Argand burner, I merely increase the flow of air to the gas by lengthening the glass chimney, or by enlarging the central aperture, or by driving the gas by great pressure through small openings, and you see how I destroy the light; and, worse still, if I mix air with the gas, so that the particles of carbon find themselves at once in the presence of atmospheric oxygen, there is no light at all. Let me blow out the gas-flame from this Argand burner, and put a piece of wire gauze upon the top of the glass chimney. The gas will now draw in the air and mix with it before it reaches the top of the chimney, and see how the light is destroyed. The same is the case with this burner of Professor Bunsen. It is a metal tube of 5 or 6 inches in length, and from $\frac{1}{3}$ to 1 inch diameter; the gas is admitted through a small aperture at the bottom of the tube, and just below this point there are four or five openings for the admission of air. As the gas issues from the jet and passes up the tube, it draws in the air, and this, mixing with the gas, burns at the top of this tube without any light, but with great heat. This indicates to us the disadvantage of allowing air, even in small proportion, to get into the gas; in fact, experiment shows that with common 12-candle gas, the loss of light with different proportions of air will be as follows:

Loss of Light from Air in Gas.

Per cent. Air.	Loss per cent.	Per cent. Air.	Loss per cent.
1	6	8	58
2	11	9	64
3	18	10	67
4	26	15	80
5	33	20	93
6	44	30	98
7	53	40	100

The practical conclusions from these inquiries are, that gas must be burnt with such a proportion of air as that, on the one hand, the particles of carbon shall be intensely heated, and shall remain as long as possible in an ignited state, and, on the other hand, they must not escape unburnt.

Relative luminosity of different burners, calculated for the same consumption.

Kind of Burner.	Pressure at Burner.	Relative value per foot Gas.
Single jet	0·50	100
Fishtail	0·25	146
Bat's wing	0·18	153
Argand	0·17	198
Bengal	0·13	214

Relative luminosity of jets of different sizes calculated for the same consumption.

Size of jet, Inch.	Pressure at Burner.	Relative value per foot Gas.
0·040	0·87	100
0·056	0·35	120
0·083	0·12	136
0·100	0·04	150
	Fishtails.	
0·036	0·47	100
0·045	0·39	194
0·056	0·24	293
0·062	0·39	319
	Bat's wings.	
0·008	1·19	100
0·012	0·49	184
0·016	0·24	232
0·020	0·16	293
0·024	0·11	313
0·028	0·09	322
0·032	0·07	316
0·036	0·04	310
0·040	0·03	307

The difficulties in arriving at these results are almost insuperable, for every illuminating agent has its own particular conditions, and requires its own especial appliances to bring out the fullest effects.

Take, for example, the effect of different kinds of burners, each burning at its best, with the same gas, (13-candle.)

Argands of 15 *holes and* 7-*inch chimney, consuming* 5 *cubic feet of gas per hour.*

Size of Inner Hole.	Pressure, Inch.	Relative value per foot Gas.
0·70	0·66	100
0·57	0·46	108
0·48	0·17	117
0 44	0·17	120
0·43	0·17	115
0·42	0·17	110

Relative luminosity of the same jet (0·04 *inch) at different pressures, calculated for equal consumptions.*

Consumption per hour, Cubic Feet.	Pressure, Inch.	Relative value per foot Gas.
0·88	0·28	100
1·31	0·43	156
1·80	0·87	195
2·33	1·38	240
2·83	1·97	264
3·53	2·68	270
	Fishtails, (0·03 *inch holes.)*	
2·00	0·17	100
3·00	0·34	109
4·00	0·50	111
5·00	0·74	110
6·00	1·00	95
	Bat's wings, (0·015 *inch slit.)*	
2·00	0·13	100
3·00	0·21	109
4·00	0·29	135
5·00	0·45	128
6·00	0·53	122
7·00	0·68	121
	Sugg's Argand 15 *holes,* (0·45 *internal diameter ; hole,* 0·05 *inch.)*	
2·0	0·04	100
3·0	0·08	143
4·0	0·12	183
5·0	0·17	202
5·5	0·18	201
6·0	0·19	196

Again, the same kind of burner, but of different sizes, will give different values.

And, again, the same burner with different pressures, and, therefore, different rates of consumption, will give different values, when calculated for the same quantity of gas.

And so also with cannel gas, although in many cases the variations are not so great as with common gas, yet they are sufficiently considerable to be serious. This is seen by the following table, which I have drawn up from the experiments of Mr. King, of Liverpool:

Relative illuminating power of cannel gas, when burnt from different burners, and in different quantities from the same burner.

Power in sperm candles (120) *per foot of gas.*

Kind of Burner.	1 ft. per hour.	2 ft. per hour.	3 ft. per hour.	4 ft. per hour.	5 ft. per hour.
Single jet	2·64	...	...	...	...
Lancashire fishtail, (No. 2)	3·23	3·59	3·66	...	...
" " (No. 4)	3 59	3·95	4·11	4·0	...
London " (No. 2)	3·49	3·61	3 89	3·85	...
Bat's wing	3·09	3 76	4·05	4·11	4·16
Sixteen-hole Argand	0·26	1·74	2·43	3·53	3·68
Winfield 28-hole Argand	0·28	2·04	3·09	3·57	3·77

What, then, is to be done in the apparent confusion of all these facts, and can any useful generalization be made of them?

In the first place, we perceive that, of all kinds of burners, the single jet is the least effective.

Secondly, we notice that, although the bat's wing and fishtail burners are not subject to so great variations in power as others, and are, therefore, best suited for common use, yet they require certain precautions to be fully effective. The best burners are those which consume from 3 to 5 cubic feet of gas per hour, and the slits and holes should be so graduated that the gas issues at a pressure of from 0·08 to 0·12 of an inch for very poor gas, (12-candle,) and from 0·20 to 0·40 for 14-candle gas, and from 0·4 to 0·6 inch for cannel gas.

Thirdly, we find that Argand burners are only fit for gas of less than 18 or 19-candle power. For very poor gas, (up to 13-candle,) the best form of Argand burner is the porcelain Argand of France, (the Bengal,) which has the following measurements:

Bengal burner (Argand) of 30 *holes.*

Total height of burner	3·150	inches.
From gallery rest to top	1·220	"
External diameter	0·886	"
Internal "	0·354	"
Diameter of circle of holes	0·650	"
" of holes	0 024	"
Height of glass	7·87	"
External diameter of glass	2 00	"

The flame is protected from currents of air by a cage or basket of porcelain below, which is pierced with 109 holes of the 0·118 of an inch in diameter. This burner requires a pressure of from 0·15 to 0·25 for the proper consumption of the gas, and the rate at which it burns never exceeds 3·5 cubic feet per hour. This is the standard burner for France, and, compared with the best English burners, the value of the light for 5 cubic feet of 13-candle gas is as 113 is to 100.

In this country the best form of Argand burner is the 15-hole steatite burner of Mr. Sugg. The measurements of it are as follows:

Sugg's steatite (Argand) of 15 holes.

Total height of burner	3·00 inches.
From gallery rest to top	1·10 "
External diameter	1·10 "
Internal	Variable according to quality of gas.
Diameter of circle of holes	0·80 inches.
" of holes	0·06 "
Height of glass	7·00 "
External diameter of glass	2·00 "

The flame is protected by a perforated metal disk placed under the gallery, the perforations being 0·08 inch in diameter, and 8 in the inch linear.

The diameter of the inner hole or air-channel should vary according to the power of the gas, thus:

For 12-candle gas	0·44 inch.
" 14 "	0·48 "
" 16 "	0·55 "
" 18 "	0·60 "

All these Argands have the holes the 0·06 of an inch diameter, and the pressure is only 0·07 of an inch instead of 0·17, as with the old Sugg of 0 04 diameter. Above 18 candles, the bat's wing is the best burner for educing the light, and it should be regulated from 4·5 feet to 4 feet, according to the richness of the gas. And now, before I leave this part of the subject, I will show you some of the contrivances which have been proposed for increasing the illuminating power of a poor gas.

You have already seen that the single jet gives proportionably less light than the double jet or fishtail, and this is because of the larger surface of the flame exposed to oxidation. In this experiment, when I bring the jets together, you will notice how the light is at once increased, the proportion of increase being shown in the diagram.

Relative illuminating power of jets separate and together.

		Relative value per foot of gas.	
Size of Jet, Inch.	Pressure, Inch.	Separate.	Together.
0·067	0·24	100	164
0·083	0·20	100	190
0·100	0·12	100	184

But the pressure may he such as to spread out the flame too much, and then it is over oxidated. To check this there are the contrivances of Hart, Williamson, and others, which are fishtail burners attached to a box stuffed with wool, or having a small aperture within, as compared with the aperture without. This offers resistance to the flow of the gas, and by making it tail a little it thickens the flame and brightens the light; but the same effect would also be produced by altering the tap, provided the tap is placed, as it always should be, at a distance of about 18 inches from the burner; in fact, if it is nearer than this, as is generally the case, there is no space or chamber for the equalization of the pressure, and the gas always burns at a disadvantage.

Again, there are contrivances on the outside of the burners—as caps, and rings, and thickenings of the top of the jet—whereby the flow of air to the gas is checked and oxidation diminished.

Even with the Argand burner, if the gas is over oxidated, as by burning it with too large an inner aperture, or with too high a chimney, or at too small a rate, the light is improved by checking the draft of air; and this may be done, as you see, by putting a cap of wire gauze over the chimney. In fact, the whole of these contrivances have for their object such an adaptation of the gas to the air, or the air to the gas, as that the flame is just short of smoking. Under these circumstances, the solid particles remain as long as possible in an ignited state, and yet at last they are perfectly consumed.

(To be continued.)

Effect of High Heat on Compound Gases.—M. H. Sainte-Claire Deville, by a series of beautifully devised and carefully executed experiments, has shown the curious fact that at very high temperatures, such as are obtained in the wind furnace or the oxyhydrogen blowpipe, gases, which have at more moderate temperatures the highest affinity for each other, become indifferent, and, if already united, separate, so that at these temperatures, for instance, steam separates into oxygen and hydrogen. To this curious and very important phenomenon he has given the name "dissociation." M. Cailletet reports to the Academy of Sciences of Paris (April 16, 1866) a series of observations made upon the gases of the iron furnace which fully confirm M. Deville's conclusions, and are of themselves of the highest importance. Thus at a distance of 8 inches inside of the tuyere hole, where porcelain and platinum were instantly melted, the gases showed 15·24 per cent. of uncombined oxygen, 1·8 of free hydrogen, and 77·86 of nitrogen; while of compounds there were but 2·1 of carbonic oxide, and 3 of carbonic acid. And when we remember that the gases had to be cooled to the ordinary temperature before analysis, and that however rapidly this operation is performed there is still time for partial combination, it would appear to assume that in the presence of free carbon at hydrogen, at the heat of fusing platinum, oxygen remains uncombined. The results were confirmed by a second series of experiments in a welding furnace. The following are the results

In the first series the gas was taken immediately above the grate, porcelain melting rapidly; in the second, 15 meters (50 feet) above the grate, between the melting point of copper (1900°) and antimony, (824°;) in the third series the gases were taken at the same point as in the second, but allowed to cool more slowly.

	I.	II.	III.
Oxygen	12 74	7·65	1·21
Carbonic oxide	2·71	3·21	1·42
Carbonic acid	2 62	7·42	15·02
Nitrogen	81·93	81 72	82·35

MISCELLANIES.

Exceedingly Hard Iron.—The *Mechanics' Magazine* says; Some years ago M. Gaudin found that by heating iron, tolerably free from carbon, with a small quantity of boron, to a very high temperature, he obtained a product which could not be forged, but which possessed extraordinary hardness. He has now found that an equally hard metal may be obtained by adding to ordinary cast iron, in fusion, phosphate of iron and peroxide of manganese—he does not mention in what proportions. The product cannot be forged, but it casts easily, and is therefore readily applicable to the construction of such machines, or parts of machines, as require in their material extreme hardness rather than tenacity. The metal so produced is, moreover, singularly sonorous, and M. Gaudin accordingly proposes it as a material for bells. He finds that a still harder metal is producible by the addition of tungsten—again he omits to say in what amount—to ordinary cast iron. He states that this tungsten iron surpasses everything previously known as a material for tools for cutting rocks, and that crystals of it will cut glass as readily as the diamond.—*Jour. Soc. Arts,* No. 685.

Artificial Ivory.—We learn from the *Les Mondes* that an artificial ivory is made in France by M. Dupré from a simple paste of *papier maché* and gelatine. Billiard balls formed of this material, though barely a third of the price of those made from real ivory, are yet so durable and elastic, that they can be thrown from the top of a house on to the pavement or violently struck with a hammer without injury. With this same paste, to which the name of Parisian marble is given, among many other things, the finest and most complicated mouldings for ceilings can be made, or capitals of columns can be constructed in any color, so as to resemble the most valuable marbles.—*Lond. Reader.*

New Process for Engraving.—I see a simple way of engraving intended to replace wood-cutting, which I will quote from *Les Mondes.* The inventor starts with a smooth plate of chalk, on which he makes his

drawing with gum-water or something else that will harden on the chalk. He then sets to work with a hard brush and scrubs out the soft part not drawn on, and so gets his design in relief. He subsequently hardens the plate by putting it in a bath of gelatine and then drying it.—*Chem. News*, No. 289.

Action of Gelatinous Phosphate of Lime.—M. Collas dissolved some isinglass in water, and divided the solution into two parts. With one he mixed a little gelatinous phosphate of lime; the other he set aside as it was. Each as it cooled became a jelly, but that containing the phosphate soon liquefied, and in thirty-six hours began to putrefy, while the simple solution of isinglass remained sweet for six days. The author made a corresponding experiment with fresh beef, and found that the admixture of phosphate accelerated putrefaction. The author is of opinion that the value of phosphate of lime as manure must be in part attributed to this action. Buried in the soil it comes in contact with nitrogenized matters, and decomposes them, rendering them soluble and easy to be absorbed by plants. It must not be considered as a passive body, simply necessary for the organization of the plant. It is also a powerful stimulant to vegetation, preparing itself the nutriment of the plant. The easy digestibility of fish the author considers to be owing to the presence of phosphate of lime, and he suggests that beef and mutton may be rendered much more digestible by adding gelatinous phosphate of lime to them. M. Collas believes, in fact, that an immense amount of good may be done by administering phosphate of lime in the form of gelatinous hydrate.—*Les Mondes.*—*Chem. News*, No. 329.

Ingredients to Atmospheric Air.—H. Reinsch stretched 18 square feet of carefully washed linen cloth upon poles, so as to form a sort of roof. Over one such roof he allowed very dilute hydrochloric acid to trickle for fourteen days, and over another a 1 per cent. soda solution for the same time. The collected liquors were then evaporated and examined. The acid liquor was first distilled. A beautiful violet-colored (an analine ?) compound passed over first, then sal ammoniac, and last, some pyrogenous products arising from the organic substances absorbed by the acid. The residue was then completely carbonized, and the ash examined. It contained traces of metals precipitable by H_2S, (Pb, Sn, or Cu ?) The aqueous extract of the ash contained Na, considerable traces of Ca and K, and doubtful traces of Mg. The hydrochloric solution of the ash contained Ca, Fe, Mn, Al, and traces of SO_3. Silica remained behind insoluble. In the collected soda liquor the author found much Cl and CO_2, with decided traces of PO_5 and SO_3. There were also traces of Ca, and much organic matter, with Fe, Mn, and SiO_2.—*N. Jahrb. f. Pharm.*, 24, 193. *Zeitsch. f. Chem.*, 1866, 31.

Improved Candles.—The late Dr. B. F. Joslyn, more than twenty years ago, gave to tallow candles a thin coating of wax, which prevented the running down of the melted tallow, and enabled a small wick to be

used, as in wax candles; and thus the use of snuffers was rendered unnecessary, and smoke was avoided. He found that a pound of tallow, properly burned, gave more light than a pound of wax. The only objection to such candles is, that there is a cup of melted tallow at the top, which may be spilled if carelessly handled. The reason of this invention is this: Tallow melts at a temperature so low that the heat of the flame melts it at a considerable distance; the capillary attraction of a small wick is therefore insufficient to draw up the melted tallow fast enough to make a good light; it is, therefore, necessary to use a thick wick. But the thick wick will not bend over, so that the air may touch it, and supply oxygen to burn it; it therefore has to be snuffed. But when the outer film is wax, it does not melt easily, but holds the tallow, so that the flame may burn close to its surface, and a small wick has sufficient capillary attraction to draw up all the tallow required for a bright flame. Some years ago a chemist in Venice made candles that melted at a higher temperature than wax, and offered them as a great improvement, in that they would not drip, to be used in churches.—*Prac. Mech. Jour.*

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Free Laboratory in France.—About a year ago MM. Fremy and Chevreul started a laboratory in France in which poor and ardent students might work, and have the advice of the two worthy professors named, gratis. M. Duruy, the Minister of Instruction, has recently made a grant of 10,000 francs, and M. Ménier has offered to supply the chemicals for nothing, and thus the cost of the establishment has been provided for, although the professors still superintend it without fee. The generosity of M. Ménier does not end with the supply of the chemicals; it is said that a few students who show special aptitude for research receive pecuniary assistance from a fund which he has placed at the disposal of the professors.—*Mec. Mag.*, July, 1865.

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Method of Fracturing Cast Iron with Water.—Advantage has recently been taken of the non-compressibility of water to effect the reduction of large masses of cast iron in France. The method of producing the fracture is both simple and ingenious. It consists in drilling a hole in the mass of cast iron for about one-third of its thickness, and filling the hole with water, then closing it with a steel plug which fits very accurately, and letting the ram of a pile-driver fall on the plug. The first blow separates the cast iron into two pieces.—*Mec. Mag.*, March, 1866.

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Indestructible Bottle Labels.—Bottle lables may be made indestructible by coating them with white of egg, and steaming them until they become opaque, and then drying them in an oven at 212°. The albumen becomes hard and transparent, and is unaffected by oils or acids. —*Mech. Mag.*, August, 1865.

A Comparison of some of the Meteorological Phenomena of JULY, 1866, *with those of* JULY, 1865, *and of the same month for* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	July, 1866.	July, 1865.	July, for 16 years.
Thermometer—Highest—degree,	101·00°	97·00°	101°
" date,	17th.	7th.	17th, '66.
Warmest day—mean,	92·33	87·33	92·33
" " date,	17th.	28th.	17th, '66.
Lowest—degree,	64·00	63·00	53·00
" date,	10th & 21st.	14th.	2, 3, '62; 3, '57.
Coldest day—mean,	69·00	70·00	59·70
" " date,	21st.	14th.	3d, '57.
Mean daily oscillation,	15·37	12·13	15·60
" " range,	4·22	4 44	3·84
Means at 7 A. M.,	76·23	74·76	73·91
" 2 P. M.,	87·31	83 44	83·67
" 9 P. M.,	78·63	76·66	76·41
" for the month,	80·72	78·29	78·00
Barometer—Highest—inches,	30·072 ins.	30·141 ins.	30·212 ins.
" date,	2d.	31st.	5th, '59.
Greatest mean daily press.	30 015	30·078	30·197
" " date,	2d.	31st.	5th, '59.
Lowest—inches,	29·501	29·537	29·443
" date,	23d.	17th.	19th, '51.
Least mean daily press.,	29·560	29·598	29·462
" " date,	23d.	17th.	30th, '56.
Mean daily range,	0·088	0·089	0·093
Means at 7 A. M.,	29 792	29·766	29·831
" 2 P. M.,	29·757	29·752	29·802
" 9 P. M.,	29·773	29·771	29 819
" for the month,	29·774	29·763	29·817
Force of Vapor—Greatest—inches,	0·980 in.	0·917 in.	0·983 in.
" date,	17th.	25th.	26th, '54.
Least—inches,	·431	·342	·255
" date,	11th.	10th.	22d, '64.
Means at 7 A. M.,	·667	·614	·612
" 2 P. M.,	·638	·605	·606
" 9 P. M.,	·696	·635	·639
" for the month,	·667	·618	·619
Relative Humidity—Greatest—per ct.,	89·0 per ct.	90·0 per ct.	97·0 per ct.
" date,	22d.	25th.	often.
Least—per ct.,	36·0	37·0	26·0
" date,	31st.	9th.	23d, '56.
Means at 7 A. M.,	72·7	70·2	72·3
" 2 P. M.,	49·3	53·3	52·6
" 9 P. M.,	70·1	68·2	69·9
" for the month	64·0	63·8	64·9
Clouds—Number of clear days,*	12	10	7·3
" cloudy days,	19	21	23·7
Means of sky cov'd at 7 A. M.,	41·6 per ct.	57·4 per ct.	58·2 per ct.
" " " 2 P. M.,	51·6	62·6	58·9
" " " 9 P. M.,	40·7	40·6	41·5
" " for the month	44·6	53·5	52·9
Rain—Amount,	2·513 ins.	2·135 ins.	3·622 ins.
No. of days on which rain fell,	12	9	11·0
Prevailing Winds—Times in 1000,	s62° 57′ w ·305	s88°42′ w ·273	s63°41′ w ·171

* Sky one-third or less covered at the hours of observation.

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FOR THE

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OCTOBER, 1866.

CIVIL AND MECHANICAL ENGINEERING.

For the Journal of the Franklin Institute.

Preservation of Wood in Damp and Wet Situations. By H. W. Lewis, University of Michigan.

GRADUATING THESIS.

No introductory apology for the theme of this paper is judged necessary. A few plain statements will show that the subject is one of vast though unheeded importance.

The annual drain which is exhausting our forests is startling when we remember the vast areas of our country utterly destitute of timber—when we learn, for instance, that "upon the 55,000 square miles of Illinois, there grows not a single pine large enough from which to fashion a board.* Statistics show that, in 1865, above 5,000,000,000 feet of lumber, 2,000,000,000 of shingles, and 900,000,000 pieces of lath were sold in Chicago alone.† Michigan and Wisconsin almost entirely supply that market. 6000 feet of pine lumber per acre is an average yield.‡ No formal calculation is necessary to show us that, with the present demand, a single generation will exhaust the supply those States can afford.

* Hunt's *Merchant's Mag.*, Feb., 1866, page 105.

† Lumber, 5.089,033,033 feet; shingles, 3,560,093,212; lath pieces, 938,297,743. —Hunt's *Merchant's Mag.*

‡ "An average estimate of the product of lumber of all the pine lands in the State is 6000 feet to the acre. Some sections will overrun, some fall short, of this amount." * * * "Seven years will exhaust all the pine lumber within five miles of any of the navigable rivers."—*The Pine Lands and Lumber Trade of Michigan*, page 4.

But the consumption increases in a rapid ratio. It has already raised the prices. Clear lumber sold for $18 per thousand in 1855, for $24 per thousand in 1860, and for $45 per thousand in 1865.* And following close on Chicago, in this trade, are Albany and Pittsburgh.†

Improvidence will soon, we fear, make us as dependent on foreign supplies of timber as is England, who has already granted numerous patents for processes promoting the durability of the lumber every enlightened nation must have.

Shall we employ those processes whose utility experience has demonstrated? Self-interest returns but one answer. But in American railway management, self-interest seems to be disregarded. While the average life of English railway sleepers is fifteen years, that of American sleepers is only seven years.‡ Allowing 2112 sleepers per mile, at fifty cents each,§ $1056 per mile of American railroad *decays* every seven years. Thoroughly impregnate those sleepers with sulphate of copper, at a cost of five cents each, and they would last twice as long. Thus would be effected a saving of $880 per mile‖ in the seven years, on sleepers alone. In the United States are 33,908·6 miles of railroad.¶ The whole saving on these lines would be $29,839,568, or upwards of $4,262,795 per annum.

Again, English engineers deride American wooden railway bridges. Eight years is their average duration.** Creosote them and they are good for double or treble that time.†† For ordinary railroad purposes they cost $40 per linear foot.‡‡ The use of Bethell's process would effect a great saving on such a line as the Grand Trunk Railway, whose wooden bridges measure 9355 feet upon the Montreal and Portland division alone.§§ Further illustrations of the importance of preserving timber from decay seems unnecessary. Let us proceed to the discussion of this desirable object.

In situations so free from moisture that we may practically call them dry, the durability of timber is almost unlimited. The roof of Westminster Hall is more than 450 years old. In Stirling Castle are carvings in oak, well preserved, over 300 years of age. Scotch fir

* Hunt's *Merchant's Mag.*, Feb., 1866, pages 106 and 107. † Ibid., p. 105.

‡ *New American Cyclopædia*, vol. xiii., page 734.

§ *Scientific American*, February 17, 1866. Also Col. Berrien's (Chief C. E. of M. C. R. R.) estimate of their cost for the past two years on the "Michigan Central Railroad."

‖ Five cents, at seven per cent. compound interest, amounts, in seven years, to eight cents. 50 cents — 8 cents = 42 cents saved *on each sleeper* at the end of seven years. $0·42 × 2112 = $887·04 saved per mile in seven years.

¶ De Bow's *Review*, February, 1866, page 207.

** *Civil Engineer's Journal*, vol. xxiv., page 282.

†† "A properly constructed railway bridge of suitable materials may be fully relied on for twenty years."—*Journal Franklin Institute*, vol. xxxvi., page 1.

‡‡ *Civil Engineer's Journal*, vol. xxiv., page 282.

§§ *Journal Franklin Institute*

has been found in good condition after a known use of 300 years,* and the trusses of the roof of the Basilica of St. Paul, Rome, were sound and good, after 1000 years of service.† After these well attested examples of preservation, the further consideration of wood in this state seems unnecessary.

Wood constantly wet in fresh water is quite as durable. Piles were dug from the foundations of old Savoy Palace, in a perfectly sound state, after having been down 650 years. The piles of old London Bridge were found sound and perfect 800 years after they were driven.‡

While the acidity of bog-water retards decay, it seems to us that part of the preservative property attributed to the stagnant liquid§ should be ascribed to the salts of metals or alkaline earths held in solution, and deposited among the woody fibres.

In the above situations, the action of natural agents cannot be improved. But in certain other conditions, man must resort to preservative processes to secure permanence of structure. For convenience of discussion we have introduced the following classification:

1. When wood is damp we have to guard against dry rot.
2. When wood is alternately wet and dry we have to guard against wet rot.
3. When wood is constantly wet in sea-water we have to guard against teredo navalis and limnoria terebrans.

1. *Wood in Damp Situations.*—When unseasoned wood is surrounded by dead air, it very rapidly decays, fine fungous growths extending through every part. After the rot has begun, the mere contact of decayed and sound wood seems sufficient to ensure, by a catalytic action, its spread through the latter. This has probably led some observers to their conclusions, that the accompanying parasitic plants, Merulius lachrymans (or L. vastator) and Polyporus hydridus, cause the decay. But the highest authorities now regard these growths as accessory, and beginning only after a suitable habitat has been prepared for them.‖ Thus the fungus acts the part of a scavenger and converts corrupt matter into new forms of life. The presence in the timber of the fungi spores is easily explained. The researches of Pasteur show that atmospheric dust is filled with minute germs of various species of animals and plants, ready to develop as soon as they fall into a congenial locality. He concludes that all fermentation is caused by the germination of such infinitesimal spores.¶ That they elude observation, does not seem strange, when we consider that some

* The *Builder*, vol. ii., page 638. † Ibid., p. 616. ‡ Ibid., p. 616.

§ *Civil Engineer's Journal*, vol. xxi.

‖ "There is no reason to believe that fungi can make use of organic compounds in any other than a state of decomposition."—Carpenter's *Comp. Physiology*, page 165. (See also *Encyclopædia Britanica* on this subject.)

¶ "Powders suspended in the air are the exclusive origin, the first and necessary condition of life in infusions, in putrecible bodies, and in liquids capable of undergoing fermentation."—See translation of Pasteur's experiments in vol. xxxii., page 9 of *American Journal of Science.*

infusoria are only $\frac{1}{24000}$ of an inch in length.* Admitting that they are only ten times the linear dimensions of their germs, the latter will be $\frac{1}{240000}$ of an inch long. But with the best microscopes we cannot perceive objects measuring less than $\frac{1}{80000}$ of an inch. These germs might find their way into the growing plant through both roots and leaves. The whole tree is thus filled with the seeds of decay, awaiting suitable conditions to spring into growing organisms. The prolonged vitality of spores, made necessary by this theory, cannot be a serious objection, when we remember the vigor of the "mummy wheat," and the unknown plants which start from the earth raised from deep excavations. Indeed, time, even when measured by centuries, seems hardly to affect the vitality of vegetable germs.

But what prepares timber for the germination of the fungi spores? Probably fermentation of the juices and semi-solids of the moist wood. For fermentation, five conditions are necessary,† viz: 1. Presence of water. 2. Temperature from 40° to 110° Fahr. 3. Presence of a ferment. 4. Presence of a fermentable body. 5. Exposure to the atmosphere.

Three of these conditions almost always prevail. Very rarely, if ever, can we maintain the temperature of any timber construction below 40° Fahr., or above 110° Fahr. Probably countless numbers of ferment spores are annually absorbed into the fluids of the smallest sapling. Completely excluding any construction above earth and water, from the atmosphere, is practically impossible. The two remaining conditions we can generally prevent.

1. We can remove the water by thorough seasoning, and in damp situations we can practically prevent its return by ventilation or resinous coatings.

Examples of remarkable durability of wood have been cited. With equal care in selecting and preparing the lumber, modern constructions might last as long. But while the wood of those old edifices was drying through years of preparation, the timber of modern constructions is translated from the primitive forest into a painted and varnished city dwelling in less than a single year's time. No wonder that in a very few decades, the whole structure is unsafe,‡ and that an odor of decay makes the mouldering rooms untenable.

* "Some infusoria are not more than $\frac{1}{24000}$ of an inch in diameter, and if we suppose the spores to be only $\frac{1}{10}$ of the parent's linear dimensions, there must be an incalculable amount of germs no larger than $\frac{1}{240000}$ of an inch in diameter. Since, according to Sullivant and Wormley, vision, with the most powerful microscopes, is limited to objects of $\frac{1}{80000}$ of an inch, we need not be surprised that we do not always see the floating germs of animals and plants."—Note by the translator of Pasteur's researches, *American Journal of Science*, vol. xxxii., page 9.

† Notes on Prof. A. B. Prescott's *Lectures on Organic Chemistry* in the University.

‡ For an account of the rapid destruction of the floors and joists of the Church of the Holy Trinity, Cork, Ireland, by dry rot, see *Civil Engineer's Journal*, vol. xii., page 303. For an account of the decay of floors, studs, &c., in a dwelling, see the *Builder*, vol. vi., page 34.

"In some of the mines in France the props seldom last more than fifteen months." *Annales des Mines.*

Thorough ventilation is indispensable to the preservation of even well-seasoned *naked* wood in damp localities. The rapid decomposition of sills, sleepers, and lower floors is not surprising where neither wall-gratings nor ventilating flues carry off the moisture rising from the earth, or foul gases evolved in the decay of the surface mould. In the close air of cellers, and beneath buildings, the experiments of Pasteur detected the largest per centage of fungi spores. Remove the earth to the foot of the foundation, and fill in the cavity with dry sand, plaster-rubbish, &c., or lay down a thick stratum of cement to exclude the water, and provide for a complete circulation of air, and lower floors will last nearly as long as upper ones.*

Various expedients have been resorted to, in order to hasten the seasoning process. Mr. P. W. Barlow's patent† provided for exhausting the air from one end of the log, while one or more atmospheres press upon the other end. This artificial aërial circulation through the wood is prolonged at pleasure. However excellent in theory, this process is not practicable. By another method, the smoke and hot gases of a coal fire are conveyed among the lumber, placed in a strong draft. Some writers recommend the removal of the bark one season before felling the tree. All good authorities agree *that the cutting should take place in the winter season.*‡

An impervious covering upon undried timber is very detrimental, for by it all the elements of decay are retained and compelled to do their destroying work. The folly of oiling, painting, or charring the surface of unseasoned wood is therefore evident. Owing to this blunder alone, it is no unusual thing to find the painted wood-work of older buildings completely rotted away, while the contiguous naked parts are perfectly sound.

In concluding this part of the subject we may say, *thoroughly season your lumber, afterwards cover it with varnish, paint, or pitch, or maintain around it a constant and thorough circulation of air.*

2. We can remove the fermentable body, or chemically change its nature.

Woody fibre consists chiefly of cellulose and lignine. The former is very durable, and the latter moulders away but slowly, when exposed to air and moisture. But permeating through these, and increasing from the heart to the alburnum, are nitrogenous substances of the sap and immature wood, mostly vegetable albumen. These are the fermentable bodies we desire to remove or change. A patented process has been proposed to wash out the albumen by water flowing in at one end of the log while a vacuum was produced at the other. Theoretically satisfactory, this method does not seem to have been adopted. Boiling and steaming partly remove the ferment spores, but *may not*

* The *Builder*, vol. xi., page 46. † *Civ. Eng. Jour.*, vol. xix., p. 422.

‡ Experiments detailed in the *Cosmos* show conclusively that winter-cut pine is stronger and more durable than that cut at any other season of the year.—*Ann. Sc. Discovery* for 1861, page 346.

"Oak trees felled in the winter make the best timber."—The *Builder*, 1859, page 138.

destroy the vitality of those remaining. For, according to Milve-Edwards, he has seen tardigrades resist the prolonged action of a temperature of 248° Fahr., and has known them to survive a temperature of 284° Fahr.* That low forms of vegetation are fully as tenacious of life cannot be doubted.

Boiling and steaming also coagulate the albumen at 140° Fahr. Although coagulated albumen is insoluble in water, the water of solution is, by this heating process, sealed up in the wood, and the cohesion of the latter is said to be diminished.

Albumen is also coagulated by sulphate of copper, pyrolignite of iron, chloride of mercury, chloride of zinc, &c. Some of the compounds thus formed are albuminates of the metallic oxides. Probably this is the reason why some of those salts are such excellent preservatives. But the researches of Kœnig† show that, when blue vitriol is employed, a certain portion of basic sulphate of copper remains combined in the pores of the wood so that water will not wash it out. The most resinous woods retain the most of the basic salt. Impregnated woods also contained, he found, less nitrogen than natural. It is even possible, he states, to remove all the azotized compounds by long immersion in the sulphate solution. The albuminous substances first precipitated by the solution, are redissolved by excess, as in case of concentrated sulphuric and muriatic acids.‡ The operation of such solutions should, therefore, be one of lixiviation. Knœig hopes, similarly, to explain the action of the chlorides. A recent experiment on animal albumen by Professor Prescott, shows that its precipitate by the chloride of mercury, *is* also soluble in excess of the chloride solution. From this we may conclude that the antiseptic qualities of the chlorides depend, at least partly, on their dissolving out the albumen.

But could all the nitrogenous substances be removed, thereby preventing fermentation, the cellulose and lignine of unprotected wood would slowly decompose. Hence the salt used should act on those substances also. According to good authority, sulphate of copper has this action. M. Weltz maintains that, after a time, the sulphuric acid leaves the base, and acting upon the timber, carbonizes it. He has seen the props in a mine, opened 1800 years ago, charred by the free acid thus eliminated and in a perfect state of preservation, while their surfaces were covered with metallic copper in regulus.§

The use of corrosive sublimate was patented by Mr. Kyan in 1832; that of chloride of zinc by Burnett in 1838. M. Boucherie has used

* "Although, in ordinary cases, the death of animals takes place when the temperature is sufficiently high to coagulate the hydrated albumen in their tissues, we know that this is not always so in case of those previously dried. I have seen tardigrades resist the very prolonged action of a stove whose temperature stood at 120° C., and in the researches of Mr. Doyère, the heat was carried to 140° C., (284° F.,) without death ensuing from the heat."—Mr. Edwards on "Spontaneous Generation."—*Am. Jour. Science*, vol. xxvii., page 405.

† *Am. Jour. Science*, 2d series, vol. xxxii., page 274.

‡ *Brande and Taylor's Chemistry*, p. 634.

§ *Annual Sc. Discov.*, 1865, p. 51.

solutions of blue vitriol and pyrolignite of iron. Easy impregnation of the wood is the great merit of his method.

Each process has in turn excited the most extravagant hopes, and neither has justified a tithe of the expectations formed. While "Kyanizing," "Burnettizing," or the use of any salt whatever, has not prevented the ravages of teredo navalis or limnoria terebrans, each of the processes named improves the durability of wood exposed to dampness. Each is, therefore, worthy of explanation here.

Kyan's specified solution* was one pound of chloride of mercury to four gallons of water. Long immersion in the liquid in open vats, or great pressure upon both solution and wood, in large wrought iron tanks, is necessary for the complete injection of the liquid. The durability of well kyanized timber has been proved, but the expensiveness of the operation will long forbid its extensive adoption.

For "Burnettizing,"† a solution of chloride of zinc—one pound of salt to ten gallons of water—is forced into the wood under a pressure of 150 lbs. per square inch.

Boucherie employs a solution‡ of sulphate of copper one pound to water twelve and a half gallons, or pyrolignite of iron one gallon to water six gallons. He encloses one end of the green stick in a close fitting collar, to which is attached an impervious bag communicating through a flexible tube with an elevated reservoir containing the salt liquid. Hydrostatic pressure soon expels the sap at the opposite end of the log. When the solution makes its appearance also, the process is completed.

He finds the fluid will pass *along* the grain—a distance of 12 feet—under a lower pressure than is required to force it *across* the grain—three-fourths of an inch. The operation is performed upon green timber with the greatest facility.§

* *Civil Engineer's Journal*, vol. v., page 202. † Ibid., vol. xiv., p. 471.

‡ *Civil Engineer's Journal*, vol. xx., p. 405.

§ As a modification of this method he also cut a channel in the wood throughout the circumference of the tree, fitted a reservoir thereunto, and poured in the liquid. The vital forces speedily disseminated the solution throughout the tree.

(To be continued.)

Cantor Lectures.—On Submarine Telegraphy. By Fleeming Jenkin, Esq., C.E., F.R.S.

From the London Journal of the Society of Arts, No. 690.

(Continued from page 163.)

LECTURE II.

Shallow and Deep Sea Cables.—The lecturer first alluded to the omission from the first lecture of any mention of the new insulators—balata, Parkesine, collodion, Mr. Mackintosh's material, and others. This omission was an oversight, due possibly to the fact that, as he

has been unable to procure a specimen of any one of these materials for examination, he had formed no opinion as to their merits. The value of a new, good, and cheap insulator would be very great. The following is an abstract of the second lecture, under the heads in the syllabus:

1. *Serving and Worming.*—Strands of hemp or jute are commonly laid or spun round the insulated core to serve as a pad or protection against pressure from the iron wires afterwards applied, and also, in some cases, to form a larger heart, allowing larger and more wires to be applied than could lie round the small insulated wire. This covering of hemp or jute is called the "serving" of the cable. When several insulated wires, to transmit distinct simultaneous messages, are included in one cable, as for short distances is frequently the case, these insulated wires are laid in a long strand, with hemp between them, to form a circular core. This hemp is called the "worming." The worming and serving were formerly tarred for their preservation against decay in water; but Mr. Willoughby Smith showed that the tar temporarily mended small faults of insulation, and might, therefore, conceal an accidental injury to the core; but tar was not so good an insulator as permanently to mend the fault, so that the tar might lead to the submersion of a fault which would otherwise have been discovered and repaired before submersion. To avoid this risk tanned hemp is now used, and is often applied wet, to increase the chance of at once detecting any accidental injury to the gutta-percha. Hemp under wires is remarkably durable, and jute also answers well as a cheaper substitute. When hemp is exposed in water it soon decays, and jute decays still more rapidly; both are liable to be eaten by animals where exposed, but not where covered by iron. A specimen was shown where a small quantity of hemp exposed by a kink, at a depth of 800 fathoms in the Mediterranean, had been attacked by a species of teredo; the part immediately adjacent, covered by iron wire, was intact. These animals exist in the Mediterranean even in depths of 1200 and 1600 fathoms. In applying the covering, care must be taken that the insulated wire be not overstrained; the simplicity of the work has sometimes led to the use of imperfect machines which might cut the gutta-percha, and to the employment of boys too young to be careful.

2. *Iron Sheathing.*—The served core is commonly protected by iron wires laid round and round in a long helix, and abutting one against another, so as to present the appearance of a simple iron wire rope. This sheathing is frequently called a spiral covering, but the wires lie in a helix, not a spiral, which is a curve like that formed by a watch-spring, not that formed by a corkscrew. There is a popular impression that this form of cable must necessarily be very easily extended or stretched; but this impression is wholly erroneous. The single helix stretches by becoming more nearly a straight line, and by gradually closing so as to include a smaller and smaller cylindrical space; if this closing be prevented, (for instance, if the wire be wrapped round a solid core,) the helix will not stretch more than a solid wire; the closing is prevented in the ordinary cables by the arrangement of the outer wires,

which abut, each upon its neighbor, so that a cross-section of the cable shows a compact iron ring. The tube formed by the wires cannot diminish in diameter, and, consequently, the helix cannot stretch more than a solid wire. This is proved by the experiments of Messrs. Gisborne, Forde, and Siemens in the "Report of the Joint Committee on Submarine Cables," 1861. Some extracts from their results are given in Table IV. The stretch of the Atlantic, Red Sea, and Malta-Alexandria cables before breaking is, as will be seen, hardly more than the stretch of a single iron wire (part II., Table IV.); the slight excess is owing to a slight diminution in the diameter of the cable due to the more perfect closing of the wires one upon another when the strain is applied. Owing to the perfect iron ring formed by the wires, the inner core is not sensibly compressed. A helix may elongate by untwisting as well as by closing in the manner described, and sometimes this defect has been alleged as the only serious one. The total elongation which could arise from this cause is the difference of length between the wire as it lies round the cable and when stretched out straight. This is about $1\frac{1}{2}$ per cent. in the Malta-Alexandria cable; but no sensible untwisting ever does occur. About forty or fifty turns are, at most, taken out per mile, and this would elongate such a cable about eighteen inches per mile, or about 0·03 per cent. When cables are recovered from great depths, no sensible change in the lay is found to have taken place. It cannot be seen that they have in any way been untwisted or stretched. Specimens of cable thus recovered were exhibited, and the following experiments shown to enforce the reasoning: First, half a ton was hung on a light iron cable of the usual form, and it was seen that no stretch occurred, although less than half the weight would have stretched the core inside 20 per cent., and finally have broken it. This proved that the strain was really born by the rigid helical iron wires outside, not by the core inside. Secondly, weights were hung on a single wire, outside a core of hemp and gutta-percha; this stretched a very little. Lastly, an experiment was tried which, to all appearance, resembled the first; but on the weights being taken off, the rope was bent and opened, and shown to consist of a mere hollow shell of iron wires, without any core whatever inside for eighteen inches of its length. This proved that the iron wires do not press injuriously on the core. In all these experiments the rope was free to untwist, but did not do so sensibly. The experiments were simple illustrations of facts well known to all practically acquainted with telegraphic cables. It may therefore be assumed that the common form of cable is not liable to stretch, but another defect—the liability to kink—has been urged against it. A kink is a loop drawn tight, or a twist in a rope concentrated at one point. Specimens of kinks were shown. A kink may be produced in any form of cable, with or without helical covering, inasmuch as a loop or twist may be produced in any form by mismanagement. A rope coiled round a drum, with one side out, may be wound off and rolled round another drum, or paid out into the sea, without receiving any twist, but if, by mismanagement, the rope were pulled off the end of the drum, it would be twisted or kinked. Simi-

TABLE IV.—*Strength and Elongation of Cables and Materials.*

PART I.—*Cables.*

(The Specifications are given at the end of the Abstract of this Lecture.)

CABLES.	Breaking strain in cwts.	Corresponding length in water. Fathoms.	Per cent. of elongation, with one-half breaking weight, per cent.	Per cent. of elongation, with breaking weight, per cent.	Weight per knot in air. Cwts.	Weight per knot in water. Cwts.	REMARKS AND AUTHORITIES.
First Atlantic..........	80	4,979	0·24	0·8	21·70	16·30	Report of Joint Committee, App. 10.
Red Sea............	65 to 87.5	3,806 to 5,112	0·16 to 0·34	0·56 to 1·16	21	17·30	Do. do. do.
Malta-Alexandria	147 " 157	4,565 " 4,874	0·2 " 0·36	0·5 " 0·86	42·70	32 73	Do. do. do.
Second Atlantic.........	154	11,000	....	2·57 " 4·65	35·75	14·0	Unpublished experiments by Mr. Fairbairn.
Steel and hemp-coated, Gibraltar...............	102·5 " 147·5	7,928 " 11,407	0·62 " 1·24	1·87 " 4·06	25·47	13·11	Report of Joint Committee, App. 10.
Iron and hemp-coated	67·5 " 75	5,346 " 6,000	0·26 " 0·77	1·80 " 3·10	24·87	12 65	Do. do. do.
Siemens' copper-covered cable.....	50	6,250	....	0·8	18·61	7·97	Mr. C. W. Siemens' unpublished information.
Allan's cable......	18·37	7,500	....	1·0	8·0	2·5	Mr. Allan's unpubli-hed information.
Ratan and stretched hemp....................	15·75	8,500	0·52	1·56	7·73	1·86	Messrs Forde and Jenkin's unpublished information.

PART II.—*Materials.*

MATERIALS.	Breaking strain in cwts.	Corresponding length in water. Fathoms.	Per cent. of elongation with one-half breaking weight, per cent.	Per cent. of elongation with breaking weight, per cent.	Weight per knot in air. Cwt.	Weight per knot in water. Cwt.	REMARKS.
Copper strand, Malta-Alex.	5·75	....	0·22	8·5	3·57	3·125	Report of Joint Committee, App. 10.
Core, Malta-Alex.........	5·75 to 7·5	2,360 to 2,826	0·28	22 to 25	7·15	3·36	Do. do. do.
*Iron wire, 0·079 in....	4·18 " 4·5	5,600 " 6,040	0·12 to 0·18	0·46 " 0·72	96 lbs.	83·5	Do. do. do.
*Steel wire, 0·079 in....	8·00 " 8·50	10,600 " 11,200	0·28 " 0·34	1·00 " 1·80	97 lbs.	84 7	Do. do. do.
Hemp and iron......	5·00 " 7·43	....	0·16 " 0·32	1·04 " 2·46	141 lbs.	....	Do. do. do.
Steel and hemp	10·87 " 11·75	....	0·37 " 0·51	2·28 " 2·70	142 lbs.	....	Do. do. do.
Hemp alone.........	2·87	....	....	....	45 lbs.	....	Do. do. do.

* Other specimens of iron and steel would be found to stretch differently. Some iron and some steel would stretch considerably more, and very hard specimens would stretch less. The above results seem to be taken from fair samples.

larly, if coiled in a tank, with one side always uppermost, although apparently without twist, it would be twisted or kinked when pulled straight out of the hold. In practice, these plans are not adopted; the cable is carried down into the tanks from a drum with one side always turned in one direction. Let one side of a straight cable be marked black, and let it be coiled into the hold, so that the black side shall always be north; then this black mark will, on the north side of the tank, be turned from the centre, at the south side to the centre, at the east and west side it will be uppermost and undermost, respectively. The rope thus coiled in will have one twist in it for every turn round the tank. In a spun rope, this twist will twist the rope tighter, or untwist it, according to the direction in which the rope is coiled; but in either case, when the rope is drawn out of the coil it comes out as it was put in—straight and without twist. The extra turn or twist is caused by coiling, and removed by uncoiling. There is one simple, universal, and sufficient rule to prevent the occurrence of a permanent twist. The cable must be taken out of the tank or off the drum, in the same manner as it is put in or on; the opposite course will always put a permanent twist into a cable, and this twist, concentrated at one point, produces a kink. These points were illustrated by elementary experiments with a piece of india rubber tubing to represent a cable. One side of the tube was painted so that a twist could readily be seen. When a cable is properly coiled in the tank, it is possible, by a severe jerk, so to mismanage the uncoiling as not to take out the twist regularly, and kinks have thus been caused by several turns being caught up at once out of the hold. This now very seldom happens. Not one kink occurred during the paying out of the Malta-Alexandria and Persian Gulf cables, or during the late Atlantic expedition, in all about 3500 knots. Even when a kink does occur, it seldom injures the cable. A specimen was shown, cut from the Dover and Calais cable, containing six insulated wires, through which, kinked as they were, messages had for years been transmitted between England and France. The common form of cables affords a good mechanical protection against injury.

3. *Iron and Steel Wire.*—The tensile strength of a cable is the sum of the strength of the wires composing it. A cable covered with good iron should bear a strain equal to two tons per pound of iron wire per fathom. Thus, a cable with 3750 lbs. of iron per knot, or 3·75 lbs. per fathom in the sheathing, should bear 7½ tons. This rule corresponds to a strength of about 41 tons per square inch. The larger gauges and inferior qualities of iron cannot be expected to bear so high a strain as this. Best best is the quality most usually specified, but charcoal wire seems to be more permanent than the inferior brands. The wire should in no case be hard or brittle. Bright wire is generally used for the smaller gauges, and black wire for the larger gauges, unless the wire be galvanized. Table V. gives the relative weights per knot of the different gauges, according to Messrs. Johnson, of Manchester. The weight of a wire per knot in pounds is nearly equal to the square of the diameter in inches, multiplied by 16,100, or say $16{,}100d^2$.

The wires are joined by welding and the cables by splicing. These operations require no special description. Welds should not be allowed in two wires of a cable at the same point, or near the same point.

Table V.—*Showing weights of iron wire of different gauges.*

B. W. G.	lbs. per knot.
00	2066·68
0	1716·48
1	1393·92
2	1212·20
3	1048·32
4	872·80
5	748·80
6	622·08
7	529·92
8	449·28
9	368·64
10	305·82
11	241·99
12	184·32
13	144·00
14	109·44
15	86·40
16	65·66
17	50·68
18	39·16

4. *Sheathing Machines.*—These apply the wire with a constant tension and so as not to twist it, keeping one side always uppermost, so that if it faces the core below the cable it will be turned away from the core at the top. To do this each bobbin holding the wire moves parallel to itself. The effect of this arrangement was experimentally shown with the india rubber tube to represent a wire. The effect of the other arrangement, in which the bobbin moves round the cable fast on a disc, as the arm of a wheel moves round the nave, or as the moon round the earth, was also shown. This arrangement twists the wire. Cables made with twisted wire are weaker and less manageable than those made with untwisted wire.

5. *Permanency of Cables.*—The wires of cables may rust or be chafed through on rocks, or be eaten through by some chemical action other than simple rusting, or they may be broken by anchors. Any motion in the water round a cable much accelerates the rusting away, and chafing depends wholly on this cause. In some bottoms, even in still water or great depths, decay does occur very rapidly, and this must be due to some other cause than simple rusting. Large wires are the natural protection to injury from the causes enumerated. Galvanizing also protects the wires from simple rust. In some situations the simple unprotected wires remain wonderfully unaltered, but protection where possible should always be given. Bright and Clark's silicated bituminous compound applied over the wires affords the best protection yet known. The Persian Gulf cable is coated with it from end to end. To ensure permanency, cables in shallow seas were now laid weighing as much as ten tons per mile, with shore ends weighing nearly twenty tons to resist anchors (*vide* England-Holland cable, Appendix). Many

heavy shore ends were covered with strands of wire instead of simple wires. Mr. Siemens proposed to apply a covering of hemp outside the iron wires and to wrap this round with a zinc armor.

(To be continued.)

For the Journal of the Franklin Institute.

Pile Driving. By CHAS. H. HASWELL, Civil and Marine Eng., N.Y.

The effect of the blow of a ram, or monkey, of a pile-driver, is as the square of its velocity, but the impact is not to be estimated directly by this rule, as the degree and extent of the yielding of the pile materially affects it. The rule, therefore, is of value in application only as a means of comparison.

By my experiments in 1852, to determine the *dynamical* effect of a falling body, it appeared that whilst the effect was directly as the velocity, it was far greater than that usually estimated by the formula $\sqrt{s\,2\,g}$, which, for a weight of 1 lb. falling 2 feet, would be 11·34, giving a momentum of 11·34 ft. lbs., whereas by the effect shown by the following record of actual observation, it would be v w 4·426 = 50 lbs.

Results of experiments made to determine the dynamical effect of bodies falling freely, 1852.

Weight of falling body, avoirdupois.	Space fallen through.	Velocity acquired at end of fall, per second.	Effect as indicated by instrument.
lbs.	feet.	feet.	lbs.
·5	·5	5·67	12·5
·5	1·	8·02	17·75
·5	2·	11·34	25·
·5	3·	13·89	31·
·5	4·	16·04	36·
·5	5·	17·93	40·
1·	·5	5·67	25·
1·	1·	8·02	35·5
1·	2·	11·34	50·
1·5	·5	5·67	37·
1·5	1·	8·02	53·
2·	·5	5·67	50·
2·	1·	8·02	71·5

Piles are distinguished according to their position and purpose; thus, *gauge piles* are driven to define the limit of the ground to be enclosed, or as guides to the permanent piling.

Sheet or *close piles* are driven between the gauge piles to form a continuous enclosure of the work.

The weight which is required of each pile to sustain should be computed as if it stood unsupported by any surrounding earth.

When the length of an oak pile does not exceed sixteen times its

diameter, it may be loaded permanently with a weight of 450 lbs. per square inch of its sectional area.

A heavy ram and a low fall is the most effective condition of operation of a pile driver, provided the height is such that the force of the blow will not be expended in merely overcoming the inertia of the pile, and, at the same time, not from such a height as to generate a velocity which will be expended in crushing the fibres of the head of the pile.

The *refusal* of a pile intended to support a weight of $13\frac{1}{2}$ tons can be safely taken at ten blows of a ram of 1350 lbs., falling 12 feet, and depressing the pile four-fifths of an inch at each stroke.

Pneumatic Piles.—A hollow pile of cast iron, $2\frac{1}{2}$ feet in diameter, was depressed into the Goodwin sands 33 feet 7 inches in $5\frac{1}{2}$ hours.

Nasmyth's Steam Pile Hammer has driven a pile 14 inches square, and 18 feet in length, 15 feet into a coarse ground, imbedded in a strong clay, in 17 seconds, with 20 blows of the hammer, or monkey, making 70 strokes per minute.

By the extended observations of Brevet Major John Sanders, U.S. Engineers, he deduced the following rule whereby to estimate the weight that can be safely borne upon a pile: "As many times the weight of the ram, as the distance which the pile is sunk, the last blow is contained in the distance which the ram falls in making the blow, divided by 8," which, when reduced to a formula, becomes

$$\frac{(\mathrm{R} \times h \div d)}{8} = \mathrm{W},$$

R *representing the weight of the ram in pounds, h the height of the fall, and d the distance the pile is depressed by the blow, both in feet.*

Here, then, is obtained a formula whereby to compute the limit of operation of a driver, which is essentially all that is required.

Illustration.—A ram, weighing 3500 lbs., falling $3\frac{1}{2}$ feet, depressed a pile 4·2 ins. Then,

$$\frac{3500 \times (42 \div 4{\cdot}2)}{8} = \frac{35000}{8} = 4375 \text{ lbs.},$$

the weight which the pile would bear with safety.

By the ordinary formula $\sqrt{v\, 2\, g}\, \mathrm{W}$, $15 \times 3500 = 52{,}750$ lbs., the computed force; hence, assuming the rule of Major Sanders as a guide, $\frac{4375}{52{,}750} = {\cdot}0814$, which may be taken as the co-efficient whereby to reduce the momentum of a ram to the weight the pile can bear with safety.

Messrs. M. Scott and J. Robertson submitted to the Institution of Mechanical Engineers, London, 1857, a paper on the "Theory of Pile Driving," of which the following are the essential points, when briefly given, viz:

The object of the investigation of pile driving is not to determine to a fraction of an inch the distance a pile may be driven, and especially so, as the resistance offered by the earth, which is the most im-

portant element, cannot be correctly ascertained, but the object is to elicit the simple and general truths upon which the system depends.

Dr. Whewell deduced—

1. A slight increase in the hardness of the pile, or in the weight of the ram, will considerably increase the distance the pile may be driven.

2. The resistance being great, the lighter the pile the faster it may be driven.

3. The distance driven varies as the cube of the weight of the ram.

Although these deductions cannot be depended upon as exact under all circumstances, they give a tolerably correct indication, and are in accordance with those which may be arrived at by general reasoning. The complication in the original expressions arises from taking into consideration in the general question the weight and inertia of the pile. The weight of the pile bears so small proportion to the resistance of the earth, that it may be neglected; for a pile 25 feet in length and 1 foot square weighs about one-half a ton, and if the fall of a ram weighing one ton is 10 feet, and the distance driven by the blow is 2 inches, then the resistance of the earth will be to the weight of the ram as 120 inches to 2 inches; that is, it will be 60 tons, of which one-half a ton is the $\frac{1}{120}$ part, and may, therefore, be neglected.

To Compute the Space through which a Pile is Driven.

$\frac{\text{R}\,h}{\text{C}} = s$, C representing the resistance of the earth. Hence, by inversion,

To Compute the Co-efficient of the Resistance of the Earth.

$$\frac{\text{R}\,h}{s} = \text{C}.$$

Weisbach gives the following formula: The resistance of the bed of earth being constant, the mechanical effect expended in the penetration of the pile will be—

$$\frac{\text{R}^2\,h}{\text{P} + \text{R}\,s} = \text{W}.$$

Taking the elements of the preceding case, with the addition of the weight of the pile at 1500 lbs., the result would be—

$$\frac{3500^2 \times 3{\cdot}5}{1500 + 3500 \times (4{\cdot}2 \div 12)} = \frac{42{,}875{,}000}{1750} = 24{,}500 \text{ lbs.}$$

The range for security is given from $\frac{1}{10}$ to $\frac{1}{100}$. Assuming, then, the rule of Major Sanders as correct, the deduction from this rule would be $\frac{2}{11}$.

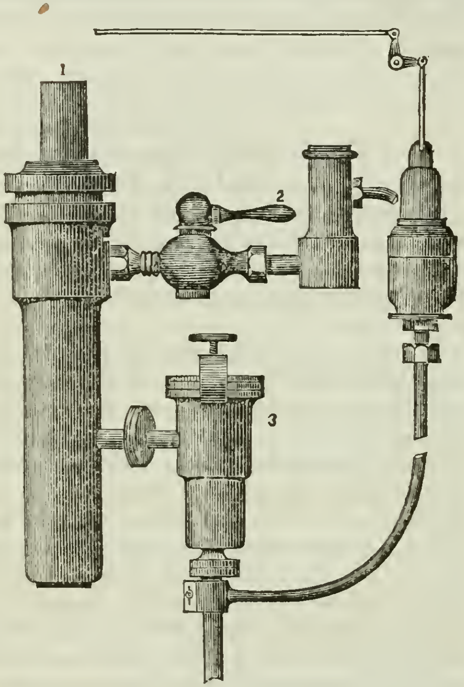
Potez, ainé, and Thibaut's Boiler Feed.

From the Practical Mechanics' Journal, May, 1866.

This apparatus is a combination of the two inventions, one called the stokers' aid, (*aide-chauffeur,*) and the other the self-acting clearing cock, (*purgeur automate.*) The former is the invention of M. Potez,

ainé, and the latter of M. Thibaut, of 34 Rue du Rendezvous, Paris. The contrivance is calculated to insure in the best manner a self-acting and regular supply of water to steam boilers, and, as a matter of consequence, will diminish the risk of explosion and the too frequent disastrous consequences.

The piece No. 2 on the illustration, the stokers' aid, is simply a tube placed laterally in communication with the tube No. 1 of the force-pump, above the clack-valve. The tube of the stokers' aid has its extremity raised to a vertical position, and is terminated by a brass mounting on which rests a sort of valve with an india rubber seat. When this valve is closed no effect is produced, and the pump works as usual; but when once the valve is, on the contrary, raised above the seat, the pump ceases to inject and draws nothing but air. To produce the alterations of closing and opening according to the required supply of water in the boiler, it is only necessary to connect by a vertical rod and a series of cranks and wires, or some like contrivance, the valve with a float in good order, so that every time that the water in the boiler will rise above the normal level the pump will cease to inject. If the pump could commence acting as soon as the water in the boiler had fallen below a certain level, the problem would be completely solved. This is managed by aid of the blow-off, (*purgeur*,) No. 3, consisting of a cock of small section, furnished by a spring-valve, which allows to escape at each stroke of the pump a portion of the air and water introduced through the clack-valve. Thus, an undue or accidental pressure is prevented from being exerted in the body of the pump after the shutting of the injection-valve. This condition being of the utmost importance, especially when the boiler is fed with water at high temperatures, this absence of pressure is all that is necessary to insure the self-action of the pump. In fact, the cock No. 3 allows the pump to act freely every time that, by the closing of the orifice of the stokers' aid or piece No. 2, the feed must again be renewed.



"We have submitted," adds M. Tresca in his report, "this double apparatus to very severe tests, since, after having assured ourselves that

it would work with cold water, we supplied the cistern of the pump with water from 98° to 100° centigrade, (boiling point,) without any irregularity happening in the feed. The working of the apparatus has been closely superintended for two months, and the accuracy with which it has constantly maintained the level of the water in the boiler to within 2 centimetres (four-fifths of an inch) of variation, enables us to give the best testimony as to its efficacy. Its employment is sure to be advantageous, at the same time diminishing the labor of the stoker. The only condition being that the boiler float be kept in proper working order."

For the Journal of the Franklin Institute.

The Practical Advantages of Superheating Steam.

By H. W. Bulkley, New York.

"Superheated" steam, or steam which has received an increase of temperature without increase of weight, by the direct application of heat, has enemies who stoutly maintain that no benefit can be derived from the superheating, as the steam has its maximum efficiency as soon as generated.

The fallacy of such statements are evident on reflection, and plainly show that those advancing and upholding them have neither practical acquaintance with the subject, nor have given it serious thought. It is clear that, as the greater part of the steam generated in boilers is obliged to pass through the water above it, on its way to the steam-pipe, it must unavoidably carry with it much water in the form of spray, *mechanically* combined, and held in suspension. When boilers "*foam*," this operation is greatly increased by unnatural causes, the delivery of spray becoming so great as to seriously inconvenience the engine, and endanger *its* safety, as well as that of the boiler. And in boilers properly constructed and carefully operated, which may be supposed to work dry steam, *much more* water than is generally conceived, is constantly carried over with the steam, and this defect cannot be *entirely* remedied, even by the most judicious arrangement of "dry-pipes," steam-drums, &c. What then becomes of this water mixed with the steam, and which has been heated at the expense of the fuel? It is evident that it is useless for *power*, and, as it has no latent heat, is very unavailable for heating or drying purposes. It cannot act otherwise than as a "clog," causing more friction in the steam by its presence, inconveniencing the operation of the engine, and tending to condense the steam with which it is associated. Now, by superheating this wet, saturated steam, it is converted into an elastic vapor by the complete and instantaneous vaporization of its surplus moisture, while its temperature is raised sufficient to preserve it from premature condensation in passing to the cylinder, or to the heating or drying coils.

The volume and elasticity of the steam is thus increased to a wonderful extent by a very moderate degree of superheating, and its subsequent operation in the cylinder is highly satisfactory.

But another advantage in the system should not be overlooked, and that is, the expansion of the steam *as a gas*, by the heat imparted to it *after* its surplus moisture has been evaporated. Although, as is evident, the *greatest* gain must ensue from the addition of the *first few* degrees (say 50) of heat, when the expansion of the steam from its previous saturated condition is very great, yet the highest authorities agree, that after it is thoroughly dried, the steam follows the laws of gases, and its volume may be doubled by the addition of 480 degrees of heat.

It is a fact proved by most accurate experiments, that the higher the degree of superheating, the greater is the economy, and if steam could be used at a temperature of 1000 degrees, its efficiency would be *very largely* increased.

Inasmuch as it is not practicable or convenient with engines, as at present constructed, to use steam at such extreme temperatures, we are unable to realize the greatest economy of superheating, but if ordinary steam of 50 lbs. pressure, at a temperature of 301 degrees, be superheated to 400, the addition of this 99 degrees of heat will augment its volume (or pressure) more than 20 per cent., and will not render it at all injurious to the lubrication or packing.

Where this superheating is effected by the waste products of combustion, the increase referred to is all clear gain, but when acquired, as is frequently done for convenience, at the expense of the fuel, a simple calculation (omitted here for want of space) shows that *even then* the economy from the expansion as a gas is from 10 to 15 per cent., *independent* from that realized in the vaporization of its surplus moisture, (as explained,) and which is as much more.

Saturated steam cannot part with any of its heat without becoming condensed, and this loss by premature condensation is often a very large per centage of the total amount of steam used. In every unit of the steam thus condensed there are lost 1000 units of heat, which have been supplied by the fuel, but have not been utilized. Superheated steam under the same circumstances might lose all of its surplus heat, but would still exist as steam.

In England, where the practical advantages of superheated steam are more thoroughly understood, and generally acknowledged, its employment is common, and is attended with most satisfactory and economical results. The steamers of the "Peninsular and Oriental Steam Navigation Company," have used superheated steam for many years, and its Directors certify that it has saved them many thousands of tons of coal.

In this country the steamers of the "Bay Line," running between Baltimore and Fortress Monroe, employed superheated steam, with an economy of 30 per cent. in their fuel. The steam, which was superheated by means of an arrangement of tubes in the uptake, was maintained at a temperature of 400 degrees in the cylinder, yet a subsequent inspection of its interior surface, after using this steam for several months, showed it to be as smooth and polished as a mirror.

The writer's experience in the practical application of superheated

steam with stationary boilers has shown that where the steam was superheated, *by the fuel*, about 100 degrees above the temperature due to its pressure, (giving a temperature of 400 degrees in the cylinder,) the saving in feed-water, or *steam*, was nearly *one-third*, and the economy *in fuel* was *one-quarter*, showing that from 5 to 8 per cent. of the fuel was required for superheating the steam generated by the remainder, thereby increasing its efficiency nearly one-third. With this temperature maintained in the cylinder, by a judicious arrangement of the superheating apparatus, the operation of the engine was highly satisfactory, no water being present to necessitate the opening of water-cocks, or bring undue strains upon the cylinder-heads or connexions. It is hardly necessary to add that no appreciable action could be observed upon the lubricants, packing, or working surfaces of the engine.

The *full* economy due to the use of steam expansively cannot be realized when it is employed in the saturated condition, owing to its partial condensation during expansion. As heat and power are correlative terms, steam cannot perform work without the elimination of a portion of its heat, besides that lost by radiation. This heat, corresponding to the work done, may be taken from superheated steam without destroying its efficiency; for it will still remain in the cylinder, pure and dry, to the end of the stroke. It can be confidently asserted that no *steam* engine is entitled to that name, if it employs a mixture of water and vapor, instead of the genuine article.

The objections sometimes advanced on the score of "want of durability" in superheating apparatuses, may be entirely removed by the exercise of a proper care in their construction and application, and by the allowance of a liberal amount of heating surface, so that it is not necessary to subject the superheaters to an undue degree of heat, which would naturally tend to their destruction. These particulars faithfully complied with, it will be found that no tangible objections can be opposed to the employment of moderately superheated steam, and when such economical results obtain from its use, it seems unaccountable that it is not more generally appreciated, and that the manufacturing public still adhere to the old saturated article, wasting by it both their time and money.

The practical advantages attending the use of superheated steam, either when used as *power*, or for *heating* and *drying* purposes, are immense, and it is to be hoped that, with the increased diffusion of knowledge, the old fogy prejudices against it may be removed, while its true merits are openly and universally acknowledged.

No. 57 Broadway, N. Y., August 29, 1866.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

Anchor-ice. By JAMES B. FRANCIS, C. E.

Articles have appeared in the May and August numbers of this *Journal* relating to the obstruction of the strainer of the inlet-pipe

of the Detroit Water-works by ice in 25 feet depth of water. As suggested by Professor Henry, this is undoubtedly an example of *ground* or *anchor-ice.* Perhaps a brief account of some of the circumstances attending this curious phenomenon, in another place, may aid in elucidating the Detroit example.

The manufacturing establishments at Lowell are driven by water-power derived from a fall of about 34 feet at Pawtucket Falls in the Merrimack River. The dam at the head of the falls sets back the water about eighteen miles to the foot of the next fall above. Usually, before the middle of December, the entire reach of eighteen miles is frozen over. In ordinary stages of the river, nearly its whole flow is diverted into the canals by the dam, and is used by the manufacturing establishments. The current in most of these canals is too rapid to allow them to be frozen over. At times, the operation of the mills is seriously interrupted by anchor-ice, the formation of which is evidently connected with the open water, as at the mills which are supplied with water from the river through canals which are frozen over, there is no anchor-ice, while at others, supplied from the same source, through canals not frozen over, great trouble is experienced. In fact, it is uniformly observed that anchor-ice is found only at or below open water. The water is usually kept flowing through the canals during the night, when the mills are not in operation, passing over dams or weirs constructed for the purpose. During some part of most winter nights anchor-ice forms, and, in severe weather, men are employed through the night, in cutting it away from the tops of the dams, in order to prevent overflows.

Anchor-ice is an aggregation of small crystals or needles of ice, forming in the water a spongy mass, easily penetrated with any hard substance. It is frequently found adhering in large quantities to the bottom and sides of the water-courses, both open and covered. In clear weather, as the sun approaches the meridian, masses of anchor-ice often rise from the bottom of the open channels and float off, sometimes with earth and small stones adhering. It is produced in the greatest abundance in cold, clear, windy nights. It unquestionably originates at the surface of the water, the necessary conditions being, that the water should be at the freezing temperature, the air below that point and the surface of the water agitated, either by a current or by the wind. In its first stage, the ice is in small detached needles or crystals; if there is little or no current, this ice accumulates at the surface and finally consolidates into a sheet; if the current is too strong to permit this, portions of it accumulate in spongy masses, and float along at or below the surface, their specific gravity differing but little from that of the water. In a current of water there is a constant intermixture of the water at different depths, producing a uniform temperature at all depths, and tending to distribute uniformly foreign matters held in suspension. This takes place even in the most uniform and regular channels. Natural water-courses are almost always irregular in form; the more irregular the more rapid will be the intermixture.

The anchor-ice being formed in small crystals at the surface, by means of this intermixture, much of that which does not aggregate in masses, is carried down from the surface, and is distributed throughout the whole depth of the stream, much in the same manner as earthy matters are carried along in suspension by currents. These crystals have a strong tendency to adhere to each other or to any other solid bodies they may come in contact with. The adherence can only take place by freezing, that is, by a new formation of ice, and here lies the mystery of anchor-ice. How can water become ice without a loss of heat?

Anchor-ice is observed to adhere to surfaces of stone or wood, over which the water is running with considerable velocity, in some cases exceeding 20 feet per second, growing up under this rapid current at the rate of an inch or more per hour. It is clearly not dependent upon radiation in the manner Dr. Wells has shown dew to be formed, for we find the piers of bridges and the interior surfaces of subterranean water-courses, where there can be no loss of heat by terrestrial radiation, covered with anchor-ice.

Faraday has shown, (*Glaciers of the Alps*, by J. Tyndall, page 351,) "that when two pieces of ice, with moistened surfaces, were placed in contact, they became cemented together by the freezing of the film of water between them, while, when the ice was below 32° Fahr., and therefore dry, no effect of the kind could be produced. The freezing was also found to take place under water; and, indeed, it occurs even when the water in which the ice is plunged is as hot as the hand can bear." It has been suggested that the union in these experiments is accomplished by a process analogous to the welding of metals. It might account for the adherence of the crystals of anchor-ice to each other, but not to other substances.

The following explanation of the process has been suggested. The formation of ice is a kind of crystallization, requiring time for its development. Anchor-ice commences to form at the surface of water, agitated either by a current or by the wind. The water being at the temperature of 32° Fahr., and the air at a lower temperature, heat passes from the water to the air, equivalent to the formation of a certain amount of ice; the water being agitated and the ice in minute crystals, the latter become mixed with the water before all the ice due to the loss of heat is formed; and, although the crystals are removed from further loss of heat, they will continue to enlarge, until an equilibrium is attained. The amount of ice formed after the crystals leave the surface may be very small, but still be sufficient to cause them to adhere, when, by means of the current, they are brought in contact with each other, or with any other solid at the freezing temperature.

If this explanation is correct, the freezing process must continue for a considerable interval of time after the crystals leave the surface, as we have found, on drawing the water out of a subterranean water-course, the whole interior surface of the channel coated with anchor-ice, with great uniformity and symmetry, and several inches in thickness. This ice must have formed before it entered the subterranean channel and subsequently adhered.

Great inconvenience from anchor-ice is occasionally experienced at Lowell. It has been stated, that the dam there sets back the water about eighteen miles, forming a quiet reach of water usually frozen over early in the winter, which prevents the formation of anchor-ice on its surface. This ice is sometimes carried out, in the depth of winter, by a freshet. In December, 1863, this happened. On the 13th and 14th there were heavy rains, causing a rise in the river, which carried out the ice and discolored the water with earthy matter. In the night between the 15th and 16th, the wind was high from the north-west, anchor ice making freely with the thermometer at 30°. At 6 A.M., on the 16th, the wind was fresh and the thermometer at 26°, the anchor-ice forming very freely. The water-wheel for moving the sluice-gates of the Northern Canal could not be started, on account of anchor-ice having choked up the orifice through which the water is drawn. No anchor-ice is ever found at this wheel when the river is frozen over. The unusual amount of anchor-ice at this time, forming at such a high temperature, was attributed to the high wind and rapid current in the river, and the great extent of open water surface above the dams on which anchor-ice could form. Part of the anchor-ice thus formed passed into the canals, where it adhered to the sides of the water-courses and orifices, greatly obstructing the flow of the water. In such a case, the frozen surface of some of the canals is very little protection, as the anchor-ice made in the river becomes so thoroughly mixed with the water that it forms part of the stream at all depths, entering the canals with the water and flowing under the surface-ice. Strainers, used to prevent other substances than water from passing into orifices, are sometimes obstructed to such an extent that little or no water can pass through them.

The circumstances attending the formation of ice on the strainer of the Detroit Water-works do not appear to differ in any essential particular from that attending the formation of anchor-ice at Lowell. The depth of 25 feet, at which ice was formed at Detroit, is greater than it is found at Lowell, where none of the canals exceed 20 feet in depth, and are generally 10 feet or less. If, however, they were 25 feet deep, we should expect anchor-ice to gather at the bottom of them, pretty much as it does now, if the surface remained unfrozen.

Gun-cotton for Small Arms.

From the London Journal of the Society of Arts, July, 1866.

Gun-cotton, though largely used for blasting purposes in this country, has hitherto, in its employment as an explosive material in guns, not been so satisfactory as could be wished. Important progress has, however, been made in the practical application of gun-cotton since its study was resumed in this country about three years ago. Very large quantities of this material have been manufactured at the works of Messrs. Prentice, at Stowmarket, as well as at the Government Gunpowder Works, at Waltham Abbey. Its application to mining and

artillery purposes, and also to small arms, has been and still is the subject of systematic experiments conducted by the Government Committee on Gun-cotton. Its employment as a blasting agent is steadily increasing in several important mining districts in England, and a considerable, though not uniform, success has attended the employment of gun-cotton for sporting purposes.

In the early applications of this material, after Schönbein's discovery of it, great difficulty arose in its use, from the want of uniformity in its quality as well as from the absence of controlling power over its action as an explosive compound. It was found, as originally manufactured, that it was a very unstable compound, decomposing readily, and thus becoming liable to spontaneous ignition. Its true chemical composition was subsequently laid down by Hadow, and further investigations have confirmed his views; and we have been enabled, through the researches of General von Lenk, in Austria, and the valuable labors of Mr. Abel, in England, to get rid of many if not all the difficulties, and by an improved system of manufacture, carefully conducted, to produce an article which experience shows to be uniform in its character, and not liable to decomposition or spontaneous ignition. The most explosive gun-cotton is perfectly insoluble in mixtures of ether and alcohol, but by varying the proportions and strength of the acids employed for the conversion of the cotton, products of a less explosive character are obtained, which are more or less soluble in ether and alcohol, (forming the well known photographic vehicle, collodion.) It appears that the imperfections in the manufacture of gun-cotton arise from the introduction of foreign matters in the cotton, which can, however, be almost entirely got rid of, and, at all events, so small an amount is left as to produce no practical inconvenience. The rapidity of its combustion makes it valuable as an explosive agent for blasting, but this very property renders it in its pure form useless as a propelling agent for a projectile, where a regulated rate of combustion is required, generating an explosive force which gradually expels the bullet from the piece. The rapidity with which gun-cotton burns in the open air admits of ready and very considerable variation by applying the simple expedients of winding, twisting, or plaiting gun-cotton yarn of different sizes; but although a mass of gun-cotton may be made to burn in a comparatively gradual manner by being very tightly wound, a charge of the material in that form acts quite as destructively when in the bore of a gun as an equal charge consisting of the yarn wound, since the pressure of the gas established by the first ignition of the charge renders the close packing of the gun-cotton powerless to resist the instantaneous penetration of the flame between the separate layers of the material. This method of controlling, though asserted in the early days to be effectual, has turned out to be inefficient. Several methods, however, have been tried. The one adopted by Messrs. Prentice consists of forming cartridges of the gun-cotton diluted (so to speak) with cotton in its original form; and cartridges of this material have been constructed for sporting purposes, which give results that are stated to be very promising. Mr. Abel's

method consists in controlling the action of the gun-cotton by consolidating the material by pressure into compact homogeneous masses, and in confining the first ignition of such compressed gun-cotton in the bore of the gun to certain surfaces. Mr. Abel accomplishes this by reducing the gun-cotton fibre to a fine state of division or pulp, as in the process of paper-making, and converting this pulp into solid masses of any suitable form and density. This method of operating affords special faculties for combining both methods—dilution and compression—of reducing the explosive violence of the gun-cotton, and the results hitherto attained are very encouraging. A systematic course of experiments is now in progress, with the object of preparing the material for artillery purposes. A third method has been adopted by Mr. Dixon, who, instead of preparing his explosive material in the form of cotton, or cotton wool, and then dealing with the material by weaving, twisting, or plaiting, combined with some diluting agent, takes the woven material in the first instance and treats this with the combined acids of the proper strength, at the suitable temperature, subsequently washing the material in running water for a lengthened period, as in the most approved methods of making gun-cotton. Strips of this material, which the inventor terms gun-cloth, of suitable width and length, are then loosely rolled with thin tissue paper between the layers, thus accomplishing the dilution necessary for reducing the rapidity and violence of the explosion, and rendering the material suitable for the expulsion of the bullet. This roll is dropped loosely fitting into a cartridge, and is thus adapted for the rifle or for general sporting purposes. Mr. Dixon, it is stated, uses also a silica solution for further diluting the gun-cotton if required, and by varying the breadth and length of the tissue paper, he is enabled to modify the rate of explosion at different portions of the cartridge, adapting it in such a way as to render it most effective for the expulsion of the bullet. Some interesting experiments with these cartridges took place a few days since at Messrs. Bussey's factory in Holborn, with excellent results. Mr. Dixon states that, by using the gun-cloth, he attains a greater regularity and uniformity of manufacture; and by his method of rolling it, combined with the tissue paper, he obtains, by a simple, easy, and inexpensive process, a perfect means of regulating and adapting the discharge to the purpose for which it is required. As compared with gunpowder the gun-cloth cartridge for equal effect weighs one-third that of the powder. It may be dipped and thoroughly soaked in water, and after drying may be used immediately with unimpaired effect. This remark, of course, applies as well to other forms of gun-cotton. The experiment was tried at Messrs. Bussey's, and a cartridge having been soaked was dried and fired within three minutes.

Looking at the progress which has already been made in the manufacture and treatment of this material in the hands of Mr. Abel, aided by the elaborate series of experiments conducted and going on under his superintendence, as well as to the practical intelligence of Messrs. Prentice, and Mr. Dixon and others, there is no reason to doubt that

the application of gun-cotton with great advantage to some of the more important purposes for which gunpowder is used will, ere long, be fully established.

On the Combustion of Gas for Economic Purposes. By Dr. Letheby.

From the London Chemical News, No. 342.

(Continued from page 212.)

And now I am anxious to draw your attention to the effect of rarefying the atmosphere, for it has been noticed that the intensity of a flame is much less at high altitudes than at low. This was particularly observed by Dr. Frankland and Professor Tyndall in the autumn of 1859, when they were making experiments on the combustion of candles at the top of Mont Blanc. They noticed that although the candles burnt at the same rate as they did in the valley of Chamounix, yet the flames were blue, and large and feeble. Dr. Frankland was so much struck with the phenomenon that he afterwards made it the subject of careful investigation. He found, indeed, that a gas-flame, like that of a candle, gave less and less light with the rarefaction of the air in which it was burning; and its results show that the loss of light is about 5·1 per cent, for every inch of diminished mercurial pressure, up to a rarefaction of 14 inches. If, for example, the light of a flame be equal to 100 at 30 inches of the barometer, it is but 94·9 at 29 inches, and 89·8 at 28 inches; and so on up to 14 inches, when it is only 18·4 per cent. of the original light. Fortunately in our photometrical inquiries the loss of light is equally great with the gas and the standard, or the variations of atmospheric pressure from day to day, or even from hour to hour, would show a marked difference in the value of light. As it is, a variation of 3 inches of the barometer must cause a difference of more than 15 per cent.; and it is not improbable that this may have something to do with visible variations in the light of the public lamps. Certain it is that the same gas in places at different altitudes will have very different values. The gas, for example, which in London has the value of 100, would be but 91 at Munich, and only 61·5 in Mexico. Indeed, the difference would be greater than this, for not only is the light actually less for equal consumptions, but as the volume of the gas expands with the rarefaction and temperature, the real value of the same quantity of gas, as measured by the meter in Mexico, would be only 46·2. Even in London the difference in the value of the light, when the barometer is 31 as compared with what it is at 28, is fully 25 per cent.; and it may well be that this difference is noticeable.

If the rarefaction of the gas and air are carried to a very great extent they cease to burn. The flame of coal gas, as well as that of a candle and of spirit of wine and ether, is extinguished at a rarefaction of about $\frac{1}{6}$th of the atmosphere, hydrogen at $\frac{1}{7}$th, sulphur at $\frac{1}{15}$th, and phosphorus at $\frac{1}{60}$. On the contrary, if the atmospheric pressure is increased, the luminosity of a flame is also increased, and it would seem that up to considerable pressures the rate of increase is in the observed proportion of 5·1 per cent. for every inch of mercurial pres-

sure; and by doubling the atmospheric pressure the light of a gas-flame rises from 100 to 252. So marked is this on the luminosity of flame, that it is not difficult to make a spirit-lamp glow like a candle, or even to make it smoke.

And then there is another circumstance which influences the light of a flame, namely, the temperature at which the combustion is going on. If the temperature is lowered, the light is also proportionally diminished. This is noticed in the flame of a candle which requires snuffing, when the charred wick and the head of sooty carbon radiates the heat and lowers the temperature of the flame. But if by any means the temperature is increased, an opposite effect is produced. I have here a contrivance which was originally designed by Mr. Bowditch, and which has been somewhat modified by Dr. Frankland. It is a common Argand burner and glass, with another glass around it, and it is so arranged that all the air which supplies the burner must pass down between the glasses and be heated before it reaches the flame. The temperature which it thus acquires is from 500° to 600° Fahrenheit, and it passes to the flame as a sort of hot blast. The result of it is that the light for the same volume of gas is increased about 67 per cent., and for equal lights it is found that there is a saving of 46 per cent. of gas.

Illuminating Power with and without the external Glass in Sperm Candles of 120.

Consumption per hour. Cubic feet.	Illuminating power without glass.	Illuminating power with glass.
2·2	......	13·0
2·6	......	15·5
3 3	13·0	21·7
3·7	15·5	......

These are the results with cannel gas, but I do not find there is a like increase of power with common gas.

Lastly, there are cases where the amount of carbon in the vaporous matter is so abundant that contrivances are needed for its oxidation. All these contrivances are plans for diminishing the supply of the combustible and increasing the flow of air. In the paraffin candle the wick is adapted for a small supply of the material; and in the benzole and paraffin lamps there are caps or deflectors, with slits for blowing the air upon the sides of the flame. In the camphine lamp there are additional deflectors in the form of a central button, and a throttled chimney for directing the air upon the inside and outside of the flame; and in the Carcel lamp the oxidation is increased by the length of the chimney. In all cases, however, the points for consideration are—the best means for effecting perfect and prolonged combustion; and, having attained this, we have to take care that the light is not destroyed by the medium of transmission. Glass is very transparent, but yet it destroys a notable proportion of light, and when the surface is ground the loss of light is often considerable:

Loss of Light by Glass Globes.

Clear glass destroys	12	per cent.
Slightly ground in pattern	24	"
Half ground	35	"
All ground	40	"
Opal glass	60	"

And, lastly, I have to refer to the methods which are adopted for estimating the value of the light of gas. These are as follows:

1. By observing the durability of a jet of gas of a given height from an aperture of a given size.

2. By ascertaining the pressure necessary to obtain a flame of a given height from the same jet.

3. By noting the height of the jet when the gas is burning from an aperture of a given size and at a uniform pressure.

4. By ascertaining the quantity of air which is required to destroy the light of a flame burning at a given rate.

5. By comparing the light with a standard flame.

The first method of testing the illuminating power of gas was often used by the late Dr. Fyfe, of Glascow, and when it was conjoined with another test, namely, the amount of condensation by chlorine, it was much relied on. The jet which he used had a diameter of the $\frac{1}{33}$d of an inch, and the flame was kept at a uniform height of 4 inches. In this way he found that a given volume of gas of different qualities burnt out in different times, thus:

Durability of a Cubic Foot.

Common Newcastle coal gas	50·5	minutes.
Wigan cannel	57·0	"
Lesmahago	65·0	"
Wemyss	75·0	"
Boghead	81·0	"

Secondly, he further ascertained that the pressure necessary to make a gas burn from an aperture of a given size, and with a flame of a given height, was also the exponent of the quality of the gas; for the better the gas the less the pressure at which it burns, and the less also is the consumption to produce a flame of a given height. For example, with a jet $\frac{1}{40}$th of an inch diameter, and a flame 5 inches high, the following were the rates and pressures of different gases:

Pressure. Inch.	Consumption per hour. Cubic foot.	Specific gravity of gas.
0·6	0·67	0·841
0·8	0·77	0·720
1·0	0·86	0·552
1·2	0·94	0·595
1·4	1·02	0·551
1·6	1·09	0·515
1·8	1·15	0·486
2·0	1·21	0·461

His deductions from these results were, that the specific gravity of the gas—or, in other words, its quality—was inversely as the square

roots of the pressures, and that the volume consumed in a given time was as the square roots of the pressures. He relied so much on this test, that he thought it capable of taking the place of both the meter and photometer.

The third method of ascertaining the value of gas is by observing the height of a flame at a given pressure from a jet with an aperture of a given size. This method has been adopted by Mr. Lowe, and it goes by the name of Lowe's jet. It is, as you perceive, a modification of the preceding, for a poor gas will burn with a shorter flame than a rich gas; and, by using a jet with an aperture of 0·04 of an inch in diameter, and a pressure of 0·5, the flame of 14-candle gas will be just 6 inches in height.

The fourth method for determining the quality of gas is by ascertaining the quantity of air necessary to destroy its light. The best instrument for determining it is the apparatus designed by M. Erdmann, and which is called a gas-prover. It is a sort of Bunsen burner, with a contrivance for graduating the supply of air. Erdmann recommends the gas to be turned on until there is a flame of a given height, and then the supply of air is admitted until the light is destroyed. This, however, is not the proper way to use the instrument. The gas should first be turned on at a given rate, viz: at the rate of 0·84 of a cubic foot per hour, and then the quantity of air necessary to destroy the light should be read off. In this way reliable results may be obtained, for the richer the gas the more air is required.

I referred in my last lecture to this diagram, which has been prepared from the experiments of Mr. King, of Liverpool.

Illuminating Power of Gas, as estimated by Erdmann's Gas-prover, the gas burning at the rate of 0·84 *cubic feet per hour.*

	DESCRIPTION OF GAS.			
	Newcastle coal.	Equal parts Newcastle and Wigan.	Wigan coal.	Boghead coal.
Height of. flame, (inches)	1·87	2·00	2·75	5·50
Number of index prover	14·72	23·39	32·78	61·84
Relative value of do....	1·00	1·59	2·22	4·15
Co-efficient of power......	0·70	0·70	0·72	0·70
Illuminating power (co-efficient = 0·7).	10·30	16·37	22·95	42·80
Do. do. by Photometer	10·30	16·35	23·58	42·96
Relative values............	1·00	1·58	2·29	4·17

Lastly, the common method for ascertaining the illuminating power of gas is by comparing it with a standard flame.

In this country the standard was formerly a wax candle burning at the rate of 120 grains per hour, but the variations in the value of the light were so great that it was abandoned; for, as a wax candle requires snuffing, it was difficult to decide when it was burning in a

proper manner. After numerous experiments extending over a year, I ascertained that, for equal consumption, the light of wax and sperm was as 14 to 16; in other words, the power of sperm was just one-seventh greater than that of wax.

At present, the standard flame in this country is a sperm of six to the pound, burning at the rate of 120 grains per hour. But for some time past this standard has also become uncertain—first, because there has been great irregularity in the construction of the wicks; and, secondly, because the sperm is being adulterated with wax and paraffin, or both. The irregularity of the wick causes a variation in the rate of burning from 116 grains per hour to 140; and the real value of the light in the two cases, when reduced to the standard consumption of 120 grains per hour, is as 96 is to 116. The adulteration of the sperm with wax and paraffin also affects the value of the light, for the former gives 13 per cent. less light than sperm, and the latter gives 23 per cent. more light. These irregularities are becoming so serious that we must ere long change the standard.

In France the standard is a Carcel lamp of specified dimensions in every particular, burning refined colza oil at the rate of 648 grains per hour. With proper precautions this standard appears to be very uniform, care being taken that the consumption of the oil is never less than 617 grains per hour, or more than 679.

And now, in concluding this part of the subject, I will direct your attention to the comparative power and value of the most important illuminating agents.

Relative Value of different Illuminating Agents.

Name.	Rate of consumption per hour.	Illuminating power (Sperm 120.)	Quantity = 14 candles.
Cannel gas..........	4 feet	18·67	3 feet.
Coal gas..............	5 "	14·00	5 "
Benzole..............	301 grs.	4·91	857 grs.
Paraffin oil..........	265 "	7·11	522 "
Sperm oil............	686 "	10·00	960 "
Colza oil..............	648 "	9·01	1008 "
Paraffin candles....	122 "	1·46	1171 "
Sperm "	132 "	1·35	1440 "
Wax "	168 "	1·43	1652 "
Stearic "	140 "	1·13	1732 "
Composite "	144 "	1·08	1858 "
Tallow "	145 "	0·83	2542 "

With regard to the value of other illuminating agents, as the magnesium light, the oxyhydrogen, or Drummond light, and the electric light, little can be said, as they vary so much with the consumption of the material.

In the case of the magnesium light, I find that when a wire the 100th of an inch in diameter is doubled and twisted, it burns at the rate of 2·4 grains per minute, and gives the light of about 69 standard sperm candles. An ounce of the wire, therefore, is equal in light-giving power

to rather more than $3\frac{1}{2}$ lbs. of sperm candles. The power of the Drummond or oxyhydrogen light varies with the combustible used. With

Coal gas	and air	it is equal to		19	candles.
"	" oxygen	"		29	"
Alcohol	"	"	"	68	"
Ether	"	"	"	76	"
Hydrogen		"	"	153	"

And the power of the electric light varies from 650 candles to 1444, the average being about 1000.

All these agents are expensive, and they give a light which is characterized by intensity rather than by quantity; but as the light is pure as well as powerful, it is frequently used for signals and for photographic purposes, and also for theatrical illustrations.

I now pass to a very interesting part of our subject, namely, the cause of the marked differences in the color of the flames of different substances; and in order that you may perceive the reason of this, let me remind you that a pure white light, with all the colors of the spectrum, is never obtained but by the intense ignition of solid or molten matter. This is so with the phosphorus flame, and with the magnesium, the oxyhydrogen, and the electric light. In all these cases there are particles of concrete solid matter in a state of intense ignition, but in the case of coal gas, and in that of burning hydrocarbons, the light is never pure unless it is intensified by very energetic combustion. The reason of this is that the particles are only heated to the point of yellow whiteness; for Dr. Draper has shown that, according to the temperature, an ignited solid (as a spiral of platinum heated by the galvanic current) passes through all the tints of the spectrum from red to white, according to the intensity of the heat, and these tints and temperatures are somewhat as follows:

Very dull red	about	970°	Fahrenheit.
Cherry-red	"	1500	"
Full red	"	2000	"
Dull red, white, or orange	"	3000	"
Yellow white	"	4000	"
Greenish white	"	5000	"
Bluish white	"	6000	"
Perfect white	"	7000	"

If, therefore, the temperature of combustion is not sufficiently high, the light is never pure. This is especially so with the creamy lagging flame of underburnt gas, and with the smokey flame of hydrocarbons rich in carbon, as benzole, turpentine, and paraffin; but if the combustion of these flames is intensified by a proper supply of air, the temperature of the ignited carbon is increased, and the light becomes purer and purer, so that when it is thrown upon colored objects it displays the tints in a more or less perfect manner. Such a flame, when examined with a prism, gives a spectrum like that of solar light with all the tints of the rainbow. This is the speciality of pure light from an ignited solid. If, however, the vaporous matter does not contain solid particles in a free or concrete form, the ignition of it produces only certain tints of the spectrum, and hence its variable colors. Examined,

therefore, with a prism, we see only those bands of color which are characteristic of the flame.

I will show you this by moistening little balls of coke with the chlorides of the following metals, and then introducing them into the colorless flame of a Bunsen burner, or, better still, into that of Griffin's blast jet; and you note how different are the tints, and how they fail to illuminate certain colors of these dyed ribbons.

Chloride of sodium	gives	a rich yellow flame.
Chloride of copper	"	a deep blue-green flame.
Chloride of strontium	"	a rich scarlet flame.
Chloride of barium	"	a pale pea-green flame.
Chloride of lithium	"	a bright crimson flame.
And a salt of thallium	"	a beautiful grass-green flame.

The chlorides are used because they are the most volatile, and they exist in the flame in a vaporous condition. These tints are so characteristic of the several metals, that they afford the most delicate means of discovering their presence; but the great fact which modern investigations have brought out is the circumstance that the spectrum of these flames consists of certain well-defined and constantly placed bands of color. This diagram will show you the spectra of the metals which I have been using; and so true and constant are the positions and tints of these bands, and so delicate are the manifestations of them, that they become the means of discovering the merest traces of the several metals. But I must not pursue this further, except by showing you the differences in the tints of this spectrum and ribbons when examined with the pure white light of burning magnesium.

And now I will briefly describe the contrivances which are used for increasing, or rather, I should say, for fully developing, the temperature of burning gas. I have shown you that the light of a flame depends on the presence of ignited carbon; if, therefore, by any contrivance, we can at once burn this carbon, and not permit it to stand, as it were, idle, in an ignited condition, the temperature must be considerably increased. This is the principle concerned in all the contrivances for developing the heat of gas.

One of the simplest means of accomplishing this is to mix a sufficient quantity of air with the gas before it reaches the place of combustion; and this is easily done by putting a cap of wire gauze upon the chimney of an Argand burner, and setting fire to the gas above it. The effect of this arrangement is that as the gas passes from the burner to the top of the chimney, it draws in a quantity of atmospheric air, which freely mixes with it and burns the solid particles. The same is the case with the burner of Bunsen, which I have already described; and you will note how strongly it ignites this platinum crucible. The same arrangement is adopted by Mr. Griffin in his reverberatory furnace, which is a Bunsen's burner enclosed in a clay chamber. I have here another contrivance of the same nature called an *atmopyre*, which is used by Professor Hofmann in his furnace for effecting organic analysis. It is a hollow cylinder of baked pipe-clay pierced with a large number of small holes. When it is placed on a small fishtail

burner, the gas, in issuing from the holes, draws in a sufficient quantity of atmospheric air to make it burn at all the apertures with a clear blue light; and thus the temperature is so much increased that the entire body of the numerous cylinders composing the furnace becomes almost white hot.

But we shall find that a still higher temperature is obtained by blowing air into a large volume of flame. This is the plan adopted by Mr. Herapath in this blow-pipe jet. Observe how intensely it ignites a mass of platinum wire; and by putting together a number of these jets, as Mr. Griffin has done, in this arrangement, which he calls a blast-furnace, you will perceive what a high temperature is obtained; and by surrounding the blast with a case of baked clay, so that the heat may be concentrated, the temperature is sufficiently high to melt all the common metals. As much as a quarter of a hundred weight of cast iron can be melted at a time in one of these furnaces, and 3 or 4 lbs. of cast iron or copper can be thus melted in fifteen minutes. Even the very refractory metals, as nickel and cobalt, can be thus fused.

And if, instead of atmospheric air, a jet of oxygen is used, as I will now show you, the temperature is still higher. This is the principle of Deville's furnace, which is a jet of oxygen blowing into a large flame of coal gas, and directed down upon the refractory substance, the whole apparatus being enclosed in a chamber of non-conductors. With this furnace large masses of platinum are easily melted, the platinum being placed upon a hollow bed of lime. I have seen a mass of platinum, weighing about 350 lbs., which had been melted in this manner, and I was informed by Messrs. Johnson and Matthey, the platinum assayers of Hatton Garden, that the mass required six hours for its fusion. During that time about 360 cubic feet of coal gas and the like quantity of oxygen were used. In fact, Deville found in his experiments at the *Ecole Normale*, that it required a little more than a cubic foot of gas and a cubic foot of oxygen to melt a pound of platinum. The temperature of the flame must be enormous; calculated from the thermotic powers of gas with air and oxygen, it may be said that it is equal to about 5228° of Fahr. when air is used, and 14,320° Fahr. with oxygen.

(To be continued.)

For the Journal of the Franklin Institute.

The Working Processes for the Reduction of the Gray Copper (Tetrahedrite) Ores at Stefanshütte, in the Comitat (County) of Zips, in Hungary. By J. L. Kleinschmidt.

(Concluded from page 172.)

Amalgamation or Extraction.—The extraction is in operation since six years at the Stefanshütte, and was started by the director of the melting works, Mr. I. Ferientschick. It is mostly used to obtain the copper from the abzugsspeiss, (see below.) Although the experiments which were made there to extract the silver from the black copper and the speiss gave a good result, the amalgamation is yet in use, partly because the amalgamation is now in successful operation, partly

because there was no pecuniary advantage visible by changing the amalgamation into extraction. In examining both methods more exactly, there is no great difference between them. In both, the chloride of silver formed is dissolved in a solution of common salt, which will be evident, by remembering that there is salt lye taken to the quickbrei, (quickmud,) and that the lye is strengthened yet by common salt. If not all the chloride of silver should have gone into solution, this will be the case in course of time, as the silver is precipitated by the copper. In the one as in the other method, the silver is precipitated by copper. In the amalgamation this silver is taken up by the quicksilver, while by extraction the most of it can be obtained pure. In the amalgamation at the Stefanshütte the copper remains in the solution, and is precipitated from it by lime, and then comes to the melting. By the extraction process the resulting copper is more pure, but the copper could be precipitated too, from the quicklye, in a metallic state, if it was not more convenient, on account of the small quantity of it, to precipitate it by lime, and to melt this precipitate together with the residues, (rückstände.) The main disadvantage of the amalgamation, therefore, is in the use of the quicksilver and the loss thereby. Since the part of the quicksilver in the amalgamation was better known by the extraction, the loss of it is only small. Most of the losses by amalgamation are occasioned from dispersed (zerschlagenem) amalgam, which dispersion flouring, again, takes place easier when the quicksilver is affected, as when this is not the case. That the dispersion of the amalgam is the main cause of the losses of silver, even by the American amalgamation, I discovered during my stay in the mines of Anqanqueo, in Mexico, in the years 1850–51. At the hacienda of St. Gabriel I found a great many tailing muds, (schlämmen,) which were deposited in the pools through which the powders took their way after the washing of the quick heaps, (montones.) These contained in 100 lbs. 1 to 3 ounces of silver. By cautious washing and addition of quicklime, I obtained a great quantity of amalgam from them. The main advantage of the amalgamation is, that the silver is sooner gained, and the production of a marketable silver can take place easier without residues than by the extraction, where it is not possible to get from a certain quantity of black copper, &c., all silver in a pure state, because a part remains always with the copper. At the Stefanshütte, therefore, such copper was amalgamated to get the silver at once from it.

In respect to the health of the workmen, those employed in the quickroom (quicksaal) were not affected from any peculiar sickness, although their white coats were colored quite green. The workmen at the roasting for amalgamation were affected with vomiting as long as they were not accustomed to the work. Those employed at the roasting for quicksilver were affected partly with nervous trembling, (hüttenkatze,) which is ascribed in common only to the lead, but particularly by running of the spittle and loss of teeth.

Speissverlechung.—Melting of the Speiss Residues with Pyrites.—The object of this operation is the production of a marketable crude antimony metal, and the extraction of the copper contained in the

residues of the amalgamation. The latter is done by transferring the copper into matte.

The roasted residues from the speiss amalgamation, which are free from silver, are melted with 85 to 95 per cent. of pyrites from Schmöllnitz, (kiese,) 12 to 18 per cent. of quartzy ores, and 120 to 130 per-cent. of rostslag. Lately, by this process, a great many of the matte obtained by the melting of the residues from extraction were worked up. A last mixture, July, 1863, consisted of—wet remains (18 per cent. water) 100, roasted matte 48, quartzy ores 28, limestone 8, copper slag 36, pyrites of Schmöllnitz 60. The mattes mentioned were roasted by 8 fires, and contained 5 to 6 per cent. of copper. Herefrom resulted matte with 14 to 16 per cent. of copper, and a speiss, (crude antimony metal,) very white, and almost free from iron.

The composition of the crude metallic antimony from this melting were, on different days,—

1.

Cu	5·73
Co and Ni	1·50
S	2·00
Sb	90·77
	100·00

2.

Cu	7·3
Fe	1·1
S	2·3
Co and Ni	1·5
Sb	87·8
	100·0

3.

Fe	trace.
Cu	11·0
Co	...
Ni	1·0
Sb	86·0
S	2·0
	100·0

4.

Fe	2·0
Cu	10·5
S	2·5
Co and Ni (in about equal quantities)	1·5
Sb	83 5
	100·0

5.

Cu	13·50
Ni	1·20
Sb	83·30
Fe	trace.
S	2·00
Co	...
	100·00

6.

Cu	9·0
Fe	1·6
S	2·4
Co and Ni	1·5
Sb	85·3
	100·0

1 and 2 from different days, large crystals; 3, 4, 5, and 6 are from the same regulus.

3, large crystal above.
4, " " below.
5, small crystallized, from the side in the midst.
6, " " " " above.

The crude antimony metal produced by this process is salable, and there is a great demand for it. Its composition shows what it can be used for. It is bought by the manufacturers of regulus antimonii in upper Hungary, who purify it still further. It has already been mentioned that cobalt and nickel are concentrated in the speiss. On account of the great amount of iron in the crude speiss, and the small quantity of the former metals in it, it was not possible for me to determinate them quantitatively.

Crude antimony metal, (Rohantimon,) produced 1862; *analysis by the wet way. White with reflecting surfaces.*

Sb	85·00
Cu	10·00
S	2·00
Co and Ni	1·50
	98·00

Method of Analysis.—The metal was reduced to fine powder, dissolved in fuming nitric acid, the diluted solution, after settling, filtered, and the copper precipitated by hydrosulphuric acid. The residue on the filter was quite white. It was dried, ignited, weighed and calculated as SbO_4. It was melted before the blow-pipe with cyanide of potassium and carbonate of soda, but no other metal was found in it. The hydrosulphuric acid precipitate was dissolved in nitric acid, and then the copper by caustic potash. The filtered fluid from the hydrosulphuric acid precipitate, after driving out the hydrosulphuric acid by boiling, oxidation by chlorate of potash, and filtration was precipitated by soda lye, filtered, ignited, and weighed, and then determinated as $(Co\ Ni)_4\ \dot{A}s$, by Plattner's method. In this case the metallic globule contained no iron. This method I found more convenient and exact than the reduction of the oxides by hydrogen, although, in this case, the oxides were not separated, as this was the case by the speiss produced from the residue of the extraction, (see below.)

Arsenic.—The ores, as well as the pyrites, (kiese,) contain arsenic, which should be concentrated in the speiss; therefore I directed my attention to it. The most simple method is to melt the speiss with cyanide of potassium in the inner blow-pipe flame. In this manner I could detect arsenic in the most samples of sulphuret of antimony from Rosenau, and the mines in the vicinity, notorious for its purity; but this was never the case with the refined speiss, (crude antimony metal;) therefore in an especial trial I concentrated the nitric acid solution, filtered off from the antimonic acid by addition of sulphuric acid, until all the nitric acid was driven out. The salts were dissolved in water, boiled with sulphurous acid, to reduce the arsenic acid, the copper precipitated by hydrosulphuric acid, filtered immediately, and treated further by hydrosulphuric acid. The small precipitate thus produced was mixed with cyanide of potassium and carbonate of soda, and melted in a sealed glass pipe. Neither by this method nor by smelting before the blow-pipe, arsenic could be detected in it. Therefore the arsenic is completely volatilized by melting in the high furnace.

In managing the melting process, I had to try almost daily the crude antimony metal produced, and as it was necessary to know the results immediately, I searched for a method to do it sooner than in the ordinary way. I found this before the blow-pipe, and succeeded to determinate the constituent parts, with an accuracy more than sufficient, in time of 1½ to 2 hours. It is the following:

From the regulus to be tried 100 to 150 milligrammes are weighed. When in pieces it is used in that state; when in powder it has to be melted with some cyanide of potassium and borax, in a cylinder of

soda paper before the blow-pipe, or in a crucible, (tute;) in the latter case by addition of some black flux. The resulting metallic globule is very cautiously melted in a small pit of the blow-pipe charcoal in the inner flame, as long as iron is absorbed by the slag. While this is the case no antimony is volatilized. The moment antimonial smoke is seen, the blowing is interrupted, and the globule covered with the cold blow-pipe hammer or anvil. The globule is separated from the charcoal, boiled with diluted hydrochloric acid and weighed. If the sample consists of one lump, the iron can be determinated by titration. For technical use the accuracy is sufficient, if the difference is considered as matte, and 26 per cent. of sulphur calculated in it. But as the crude regulus, free of iron, contains 2 per cent. of sulphur, this quantity must be calculated anyhow. Some practice having been gained in this manipulation, the resulting globule differ not a half milligramme. Now the blowing, by addition of some borax, is continued. The borax pearls show no more trace of an iron reaction, a great deal of antimonial smoke emanates, and the globule burns by itself. The smoking ceases after some time, a new piece of borax-glass is taken, and the resulting beads gathered, which show cobalt and then nickel reaction. By comparing them with beads of a certain amount of cobalt and nickel, it is possible to estimate both metals very near. By some practice a copper globule can be obtained at last, free of nickel and antimony, which has lost very little copper. This is hammered on an anvil, whereby it must not get any edge cracks, and weighed. The difference without cobalt and nickel, and 2 per cent of sulphur, gives the antimony.

The above analyses, 1 to 6, have been made by this method. They show that in one and the same regulus (könig,) the constituent parts are not uniform, but that they are differently arranged in the crystals. The surfaces of the great crystals are blue-white, reflecting, and somewhat rough. The crude antimony metal is the more blue, when containing more copper, and the more gray, when iron is prevalent. The small crystals seem to be formed by rapid cooling, and therefore mainly on the margin, the large ones in the middle. The workmen recognise at once its quality from the smoke which emanates after the matte has been taken off. The stronger it smokes the more antimony it contains. The mattes obtained by this process contain 14 to 16 per cent. of copper. They are partly roasted with 5 or 6 fires, and are melted with the black copper residues from the amalgamation. According to the method before the blow-pipe, mentioned above, it was thought possible to work up the speiss in the spleiss furnace, by volatilizing the antimony, after the speiss residues are melted down in a high furnace. But the experiments were soon discontinued; first, because the process was too expensive, as the copper had to be subjected to a very long and intense heat, to drive away the antimony, but more yet because a copper resulted which could not be used for any practical purpose.

When these mattes are worked by themselves, by roasting them according to the method of the Phönixhütte, with 8 to 9 fires, and then melting to black copper, the latter has the following composition:

Speiss Rückstand Verlechungs Schwarz-kupfer. (Black Copper from the Residues of Amalgamated Speiss by Melting them into Matte, from the Matte of 1864.)

Cu	72·64
Sb	23·09
S	0·99
Co	0·10
Ni	0·10
Fe	3·08
	100·00

Method of Analysis.—1 gramme was dissolved in aqua regia, the acid evaporated until only a small quantity of chlorhydric acid was present, dissolved in water and tartaric acid, the filtered solution precipitated by chloride of barium, (S in subst. 2 mgr.,) copper and antimony precipitated by hydrosulphuric acid, the copper in this determinated by titration, the filtered liquid boiled with sulphuric acid, and chlorate of potash, and ferric oxide, oxide of cobalt, and nickel, after the separation of the sulphate of baryta precipitated by soda lye. After weighing, (47 mgr.,) the precipitate was melted with arsenic, &c., and cobalt and nickel separated before the blow-pipe, (Co and $Ni)_4$ As = 3 mgr., ferric oxide from second trial precipitated by ammonia, (44 mgr.,) antimony by loss. The black copper has a "speissy" appearance, color light-gray, here and there changing in brass-yellow. The analysis shows that these black coppers contain more cobalt and nickel than the black copper produced from the residues of the argentiferous black copper, and the copper produced from them is inferior to the copper from argentiferous black copper, (rückstands kupfer.) The only way to improve the quality of these coppers would be to roast the matte only so far that by their melting, a small quantity of black copper (speiss) is produced, and to work up the latter with the speiss from the refining slags, (abzugsspeise,) which, it is intended, will hereafter be done.

Refining Slags, (*Spleissabzüge.*)—The refining slags contain 20 to 25 per cent. of antimony; therefore they must be worked up by themselves. It is not possible to melt them by an addition of basic slag and lime in a shaft furnace, and to refine the resulting copper in the spleiss furnace; thereby an inferior copper is obtained, and the refining in the spleiss furnace takes too long time and costs too much fuel. The method in practice now is to melt the refining slags with pyrites, (kiesen.) For this purpose they are melted with 70 to 80 per cent. of pyrites from Schmöllnitz, 10 to 15 per cent. of quartzy ores, and 90 per cent. of slags from the melting for argentiferous black copper, in a shaft furnace, and copper matte containing 36 to 38 per cent. of copper, and speiss is the result. The composition of the latter is—

Abzugsspeise. XI. Abs. (1st party to extraction.)

Co	0·74
Ni	1·15
Cu	37·50
Fe (Ag trace only below the muffel,)	11·69
S	3·19
Sb (from the loss)	45·73
	100·00

Method of Analysis as above.—The composition of the speiss shows why by the simple melting of the abzüge (refining slags) no good copper can be produced. The cobalt and nickel, in combination with the antimony, render the copper brittle and not manageable under the hammer. To make a good copper from the refining slags it is best to carry them into the speiss, that is, to combine them with the antimony, whilst most of the copper combines with a part of the sulphur of the pyrites (kies) forming matte.

The copper mattes obtained hereby contain 36 to 38 per cent. of copper, and are roasted either with four fires, and then added to the residues of the amalgamation of the black coppers, as stated above, or roasted with 8 or 9 fires and melted to black copper, and the latter refined by itself. The copper obtained in the latter manner is of inferior quality to that from the residues of the black copper amalgamation, but it contains only such minute quantities of nickel that the latter could not be determinated.

Abzugs Schwarz-kupfer. (Black Copper from the Refining Slags from the Mattes, March, 1864.*)*

Cu	84·52
S	1·06
Fe	1·58
Co	0·18
Ni	0·27
Sb	11·30
	98·91

Hammergaares Abzugs-kupfer. (Toughened and Refined Copper from the preceding Black Copper, March, 1863.*)*

Cu	98·33 by loss.
Sb	1·67
Ni	trace.
	100·00

The black copper has a dented, hackly fracture; color gray, in a great many places copper-colored. It can be stamped, but only to small pieces, not to a fine powder, because it gets flattened. From the composition of the black copper it is visible that it contains more cobalt and nickel yet than the black copper of the speiss residues of the amalgamation from the mattes, (speise-rückstands-verlechungs-kupfer,) which is in accordance to the cobalt and nickel in the speiss from the refining slags (abzugsspeise), because while the crude speiss contains so small quantities of cobalt and nickel that they could not be determined. These metals amounted in the speiss from the refining slags to 0·74 per cent. of cobalt, and 1·15 per cent. of nickel.

Black Copper.—Method of Analysis.—It was dissolved in pure nitric acid; the residue, after weighing, melted with cyanide of potassium, &c., whereby no other metals were found; the solution precipitated by hydrosulphuric acid, and in the precipitate the copper determinated by titration; cobalt and nickel were precipitated together with the ferric oxide by soda lye, weighed, arsenicated, and cobalt and nickel determinated and separated before the blow-pipe.

Toughened Copper.—It was dissolved in fuming nitric acid, and treated as the preceding. The antimony globule before the blow-pipe gave a small nickel reaction. The solution was precipitated by

hydrosulphuric acid, the precipitate filtered, and to the filtered liquid, smelling after hydrosulphuric acid, soda lye added in excess, whereby it became quite black. It was put away until the precipitate was settled, and the liquid above it was clear. The precipitate was filtered, roasted, to drive away the sulphur, and melted with arsenic and cyanide of potassium; whereby such a small nickel globule was obtained that it could not be weighed. By using the same method in the analysis of the copper from the ordinary black copper residues, the liquid turned black, but the resulting nickel globule was even smaller yet than the preceding one. The silver contained in these coppers, being without influence to the processes, was neglected in the analyses.

It requires 36 hours in the spleiss furnace to refine the copper from the refining slag. The process in refining is somewhat different from that described above. The black coppers are roasted after warming for 12 hours, until in the last hour they slowly melt together. Then the proceeding is the same as above; but in the 30th hour the poling is commenced and repeated every half hour. The slag produced at last is very liquid and contains 63·5 per cent. of Cu.

The great amount of cobalt and nickel in these black coppers explains why it takes so much time to refine them. The oxides of cobalt and nickel, particularly the latter, form, with the oxides of antimony, a cover on the surface on the molten copper, through which the antimony cannot escape. The refining slags (abzüge) of this, as those of the preceding copper, are treated like those of the black copper of the amalgamation residues. The mattes hereby produced are worked up with the other mattes from the refining slags, (abzüge,) and the speiss is added to the speiss from the refining slags, (abzugsspeise.)

Working up of the (Abzugsspeiss) Speiss from the Refining Slags.—This is the last operation to be done. There are now in use for this purpose two methods, the "verlechung" (to melt them to matte,) and the extraction, or to extract the copper in the wet way. The proceeding with the first is equal to that of the "verlechung" of the roasted amalgamation residues of the speiss. The mattes are roasted and the speiss sold. But as the copper produced from these mattes was never of the quality of the others, the "extraction" was lately introduced.

For this purpose the speiss is stamped, and the coarse powder roasted in a reverberatory furnace of the same construction as those of the amalgamation, with addition of 10 per cent. of poor matte, and placed in quadrangular boxes, which have below a layer of birch brushes; over these a hurdle work of willows, covered by sheeting. Over these powders are pumped, first, a solution of common salt of 15° B., warmed to 180° to 200° Fahr., afterwards, the lye, deprived of copper, (see below,) which runs from the iron, until they are quite covered. The lye running from the powder boxes flows to a filter box, wherein the fine powder particles, which have been carried along with the current, separate, then through some boxes of fine granulated copper. These boxes have a depth of 3 feet, and are connected by pipes ascending from their bottom, so that the lye must sink through the layer of granulated copper, to ascend the pipe, and run into the next box From these it runs to the copper precipitating apparatus, a box 19

feet by 10 feet, and $1\frac{1}{2}$ feet deep, divided by traverse planks in kennels 1 foot wide. The planks alternately leave a space of 2 inches between them and the walls of the box, so that the lye has to perform its way in zigzag. These canals are divided by boards, which stand alternately at a distance of 21 inches from the bottom and the upper level of the fluid, into cells 2 feet long, so that the lye has to ascend and descend in them. The first cells are filled by gray cast iron pieces, the last by sheet iron chips. The lye passing hot over the iron, the copper is rapidly precipitated, and the way over the iron need not to be so long as that in Schmöllnitz, where the fluid is cold, contains less copper, and must be deprived of every trace of the latter, because it is not used any more. From the sheet iron, the lye, deprived of its copper, runs to a reservoir, from which it is pumped again to the lye kettle, where so much common salt is added, as to return the lye to its former strength. Warmed it runs to the powders, which process is continued until the copper is extracted as much as possible. When the roasted materials contain silver, this is deposited in the first boxes, partly upon the granulated copper, partly on the cement copper. When argentiferous speiss is roasted to extract silver from it, 10 per cent. of salt are added in the lower hearth, but this is not necessary. The formation of chloride of silver and the solution of it are so perfectly performed by those substances containing much copper, that from the speiss of the refining slags (abzugsspeise) silver is precipitated, but it is necessary that the roasting of the powders in the first time is done in the lowest temperature, and every metallic particle destroyed, to expect a perfect extraction of the silver. There is no need to destroy the sulphuric acid salts, as in the amalgamation, where it must be done on account of the quicksilver. Here they are necessary to the process; therefore the fire is at last increased only to a dark-red heat, and very soon diminished, to draw out the charge an hour afterwards.

The Lye.—The speiss, roasted with matte, remains moistened 14 days to 6 weeks in a room, before it is put in the boxes for extraction, in which time copper and iron salts are formed. The decomposition is increased, when common salt or lye free from copper is added. These powders, containing sulphuric acid salts in great quantity, when extracted by a solution of common salt, and the filtered liquid evaporated by about 80° Fahr., give a salt crystallizing in cauliflower-formed yellow masses, (crystals.) This salt is everywhere visible in the extraction of the Stefanshütte on the powder boxes and the precipitating apparatus. After crystallization of this salt, by further evaporation, common salt crystallizes, which always must be in excess. At last green chloride of copper remains, containing not a trace of an iron salt. The yellow salt, covered with boiling water on a filter, yields an acid liquid, the residue on the filter contains soda, but by long and continuous washing with boiling water, pure ferric oxide at last remains. At 32° Fahr., glaubersalt crystallizes from the solution, and the fluid contains sesquichloride of iron and free acid. The crystals once formed, at a temperature below 32° Fahr., the yellow

salt appears not more during the process of evaporating at 80° Fahr., but crystals of glaubersalt. The specific weight of the lye has no influence on the formation of this latter, if the temperature is above 32° Fahr. To lye of 12° B., I added common salt until the specific gravity of it was 18° B., but in 8 days, at a temperature of 60° Fahr., nothing but gypsum crystallized from it, the lye of 12° B. gave, at 32° Fahr., large crystals of glaubersalt. The lye from the copper boxes running over iron, is by it deprived of its copper. After being warmed it passes again over the powder, and copper lixivates from them to commence the same circulation anew. Coming from the iron it contains only ferrous salt, and is almost without color. Exposed to the air it becomes turbid, basic salt is precipitated, and the color turns yellow. It has been the opinion that, free acid and ferric chloride being formed by this process, the lye obtained the capability to dissolve the copper in its different combinations in the roasted powders. The following experiment explains the process in the extraction boxes:

On a filter I treated roasted gray copper ores, free of iron and veinstone, with boiling lye from the extraction, which, by digestion with sheet iron and some muriatic acid, was quite colorless and free of copper. The filtered lye, in getting cold, deposited small white crystals of subchloride of copper. Its color was green. It contained, therefore, both subchloride and chloride of copper, (cuprous and cupric chlorides.) The residue on the filter was a fine brown powder, and quite different in its aspect from that when a ferrous salt is precipitated by soda, and the precipitate oxidizes in the air. The residue on the filter consisted of ferric oxide, contained no silver, and only 2 per cent. of copper, so that the double salt containing ferrous oxide changes simply with the oxide of copper in the roasted powder, ferric oxide remaining, $3\,CuO + 2\,Fe\,Cl = Cu_2\,Cl + Cu\,Cl + Fe_2\,O_3$. If metallic copper is contained in the powders, this is dissolved, the cupric chloride being changed into cuprous chloride, the powders containing silver, the chloride of copper changes the silver into chloride, being reduced to subchloride of copper. Both are soluble in a solution of common salt; therefore it is necessary that the lye contains a great excess of salt, which must be added as soon as the white flat crystals of subchloride of copper appear on the mouth of the pipes leading to the boxes containing the granulated copper. The formation of the yellow salt explains why in summer, when no glaubersalt is formed, a loss of 6 lbs. of salt to 100 lbs. of speiss powder is endured. The above double salt is not perfectly decomposed by washing the speiss powders with hot water, and soda remains in them. In winter, when the lye, after the precipitation of the copper, is brought into a cold room, glaubersalt crystallizes, and it contains ferrous chloride, which changes to ferric chloride. Twice every week the copper is taken from the precipitating apparatus, the iron brushed off, to remove the carbonous matter, washed by water and put back to its place. The cement copper is washed by water, to separate the basic iron salts which the copper always contains. The residues, after being exhausted in this manner, contain yet 6 to 8 per cent. of copper. The resulting cement copper is melted in the spleiss furnace by addition of some upper

mattes, and, after they got spleissed and cold, put anew in the spleiss furnace, and refined in the ordinary way. In this manner copper of first quality is produced. When the residues, for the purpose of obtaining the copper from them, are roasted once more under addition of 10 per cent. of poor matte, and extracted as above, the precipitated copper has a more black color, the refined and toughened copper was falling to pieces. By forging under the hammer the composition is—

Refined and Toughened Copper from the Second Extraction of the Speiss from Refining Slags, Falling to pieces, Hammered Cold. Analysis by the Wet Way, Cu by Loss.

Sb	0·533
Ni	0·288
Cu	99·178
	100·000

Black Copper from the Refining Slags (Abzügen) of this Copper, (Crucible Grain,) Falling to pieces, Hammered Cold. Analysis by the Wet Way. Cu by Loss.

Ni	2·87
Sb	4·10
Cu	93·03
	100·00

From both of these analyses it is evident that the bad qualities of this copper are produced by an amount of nickel of not quite 0·3 per cent., by the combination of this nickel with antimony; while in the refined and toughened copper from amalgamation remains 1·01 per cent. of antimony, and in the copper from the refining slags, (abzugskupfer,) which is perfectly fit for a great many purposes, and even in demand, is 1·67 per cent. of antimony. It amounts in the copper of the second extraction to 0·533 per cent. only. The lye contains cobalt, (I succeeded to isolate it;) therefore first the silver, then copper, next the nickel, and finally the cobalt are dissolved by the lye, and again they are in the order, Ag, Cu, Ni, Co, precipitated by the iron, the two last, perhaps, in combination with antimony. The last 6 to 8 per cent. of copper are difficult to extract, and the resulting copper, as shown above, has such bad qualities that it neither can be sold, nor mixed with the other, because it spoils that, too; therefore to obtain the copper from these residues, it is necessary to melt them with pyrites, separate the antimony as metal, and to transfer the copper into matte. Such mattes are very poor. They contain only 5 to 8 per cent. of copper. They are roasted in 7 to 8 fires and added to other processes, as mentioned above. The speiss thus produced has the composition—

Crude Antimony Metal from the Residues of the Extraction of the Speiss from Refining Slags; Gray, Fine Grained, Produced July, 1862. Analysis by the Wet Way. Co. and Ni. Separated before the Blow-pipe.

Cu	13·20
Fe	13·68
S	3·33
Sb	67·45
Co	1·00
Ni	1·00
	99·66

RESULTS OF THE MANIPULATION AT THE STEFANSHUTTE.

	Ores delivered.					Average produced.				Consumed.		1 lb. copper produced with charcoal.
	Sparry.			Quartzy.		Yield in 100 lbs.		Spleissed Copper.	Fine Silver.	Charcoal.	Wood.	
	Ores.	Copper.	Silver.	Ores.	Copper.	Ag.	Cu.				Klf. a 100 Cu. ft. solid wood.	
	Cwt.	Cwt.	Mrk.	Cwt.	Cwt.	Ozs.	Lbs.	Cwt.	Mrk.	Cwt.		Lbs.
1855	73037	7920	5818	14162	679	0·63	9·85	7991	5758	92345	2550	11·55
1856	63708	6922	6326	17314	781	0·61	9 50	7755	5540	91506	2812	11·80
1857	54422	6136	6751	15480	630	0·99	9·67	7021	6595	73781	2530	10·50
1858	52108	5703	5095	15310	651	0·60	9·42	6755	5097	67970	2523	10·16
1859	53548	5957	4600	16437	709	0·68	9·53	7633	4950	75513	2444	9·87
1860	54119	6420	4788	17885	734	0·70	9·92	7792	4983	75446	2191	9·68
1861	53692	6467	4422	18578	791	0·65	10·14	7848	4847	72542	2141	9·24
1862	49189	5863	5221	16831	790	0 85	10·07	7729	5574	66579	2169	8·61

The same, produced February, 1863 ; *White, with Reflecting Surfaces. Assay before the Blow-pipe.*

Cu	6·8
Fe	4·5
S	2·0
Sb	84·7
Co	0·6
Ni	1·4
	100·0

The progress made in the manufacture of the crude antimony metal is evident from these analyses. While the first produced contained 13·68 per cent. of Fe, the quantity of it in the second was only 4·8 per cent., and the copper has fallen from 13·2 per cent. to 6·8 per cent.

The residues from the extraction of the speiss amount to 130 to 140 per cent. of it, (dry weight.) By the melting of them with 60 per cent. of kies, (pyrites,) not only a great quantity of charcoal is used, to reduce the oxides; but iron is introduced in the melting process, too, (precipitating iron and pyrites together almost the weight of the speiss,) so that in some cases it was necessary to use pure quartz, in want of poor quartzy ores. From both causes it is cheaper to melt the abzugsspeisse (speiss from refining slags) with pyrites, as stated above, and treat the produced mattes, as will be shown in the description of the processes of the Phönixhutte.

On National Standards for Gas Measurement and Gas-meters.

By George Glover, Esq.

From the London Journal of the Society of Arts, No. 424.

(Continued from page 123.)

The dry gas-meter has been brought to its present condition of excellence by successive stages. The essential improvements, invented by Mr. William Richards, and patented by Messrs. Croll and Richards in 1844, consisted in the introduction of the diaphragm and the direct action of the disk. The theoretical accuracy of the principles, which the invention of Mr. Richards involved, time and experience have fully established. The patentees, however, failed to reduce those principles to practice in producing a good and durable instrument, and they abandoned its manufacture. Mr. Croll having secured the patent, Mr. Thomas Glover, in 1845, commenced the manufacture of the meter, as Croll & Glover's patent dry gas-meter, and ultimately he manufactured it as his own, having from time to time introduced such improvements on the meter as experience pointed out to be necessary to render it a reliable gas-meter. To him belongs the merit of having imparted to Mr. Richards' invention a real and practical value by the production of a correct and durable instrument.

And here I may be allowed to refer to certain improvements made in the dry gas-meter by myself. The meter of Messrs. George Glover & Co. has a large and distinct dial, which shows at a glance the number of cubic feet of gas passed, the number of the meter's capacity per hour and per revolution, and the marks of identity, all of

which the "Sales of Gas Act" requires, the maker's name, and the date of the manufacture. These points of information are inscribed on an enamelled dial in legible and indellible characters; and they are necessary for reference, especially when disputes arise between buyer and seller, in which case the marks of identityand capacity are essential. These should not be entrusted to flimsy badges of thin metallic substances, which become tarnished and illigible, accidentally fall off, and can easily be transposed for fraudulent purposes.

A slot is introduced in our manufacture, and a pin which connects the valve and valve-rod. This facilitates the adjustment of the two sets of valves necessary to the uniform flow of gas, without which steady lights cannot be obtained. The attempt to adjust the position of the valve-pin by giving a curvature to the valve-arm is very objectionable. The valve-arm has to be made soft, so as to admit of this finger and thumb adjustment, its protracted immersion in gas rendering it still softer. The result is that the rod becomes more or less curved during the action of the meter as it transmits force, in the direction of its length, as a thrust or as a pull alternately.

Another improvement I have effected is the introduction of a slot in the tangent of the meter, and the placing a shoulder or rest on the tangent pin, the flat surface of which rests on the upper surface of the tangent. The pin is secured in its place by a screw from below, the flattened head of which fixes it firmly at any desired point of the slot. This arrangement keeps the pin in a perfectly vertical position, and admits of the meter being registered with care and precision. To secure uniformity we stamp the cases and internal parts of our meters. This we do by steam power, and we are thereby enabled to effect a saving in their production.

To reduce to practice the idea of a machine for the accurate measurement and correct registration of gas the experience of half a century has shown to be no easy problem. The construction of a good and durable dry gas-meter involves a multiplicity of chemical and mechanical considerations, to each of which its due weight must be assigned.

As I said, when speaking of the standards, a subtle, invisible, elastic, aëriform body, very complex in its chemical constitution, susceptible of change in condition and volume from slight variations in temperature and pressure, has to be accurately measured, and the result of that measurement must be accurately recorded. The instrument must be self-acting, and must act in a closed chamber, continuously or at intervals, requiring no adjustment or interference of any kind. All its parts which come in contact with gas must be made of anticorrosive metal; while the materials, forms, and combinations of its different parts must be so arranged and so adapted to each other that, when put together as a whole, it shall work easily, steadily, and correctly.

Many have a strong prejudice against using leather in dry gas-meters. This prejudice is well-founded when the leather is not properly prepared for gas, or when it is used as a hinge for the doors of the measuring chambers in meters of oblique action, when it is liable to

give way. But when it is properly prepared for the reception of gas, which contains carbolic acid or creosote—an excellent antiseptic for animal texture—and its flexibility is used to a limited extent, it will remain sound and pliable for any length of time. The dry gas-meter, in fact, obviates, I respectfully submit, all the objections to the wet meter. I may be allowed to state *seriatim* its different points of superiority.

1. It measures accurately, and does not vary in its registration.

2. It does not cause jumping, or sudden extinction of the lights, the former a common source of annoyance, the latter not free from danger, especially in large assemblies, and on railway lines where signal lights are used.

3. It does not require to be opened that water may be put into it; thus escape of gas from the plugs being carelessly left open, always offensive, and occasionally producing explosions, are averted.

4. It cannot be tampered with without showing distinct evidence of having been so; and it is thus free from the many temptations and facilities to fraud which are characteristic of the wet meter.

5. It does not allow the gas to pass without being registered, a source of much greater loss to companies than is commonly supposed, and which is caused by the water-level falling to a point at which the gas passes unregistered.

6. The frequent supply of water now rendered necessary by the small range of error allowed by the "Sales of Gas Act," the vigilant attention required to prevent fraud, and to ascertain when the gas is passing unregistered, need three times the number of inspectors requisite where dry meters are used; whilst in testing meters the expense of inspectors and instruments is three times as great with the wet as with the dry meter, which thus effects a great saving to gas companies and to local authorities.

7. The dry meter does not require to be placed in the basement or lower part of the house, but may be put anywhere. The attempt with wet meters to prevent jumping of the lights by giving all the pipes a gradual ascent to the meter, so as to admit of the water trickling back into it, besides being impracticable, is expensive and detrimental to house property.

8. The dry meter works with less pressure than the wet. Not only is a saving of gas thus affected, but in large cities where, during the winter season, dense fogs occur, the low pressure in the mains during the day is not adequate to move the wet meters so as to supply enough of gas for the burners, and only small smokey flames can be obtained from them, but with the dry meter under all these circumstances there is sufficiency of light. Thus interruptions to business are averted.

9. The action of the dry meter cannot, like that of the wet, be arrested by frost, causing total extinction of the lights. This makes the dry meter especially advantageous on railway lines, precluding, as it does, the necessity of keeping up fires near the meter during a severe and protracted frost. This applies with peculiar force to countries

where the cold is intense, and where the evil is attempted to be combated by putting spirits or glycerine into the meter.

10. Made of anti-corrosive metal, and not subject to the corrosive power of the chemical constituents of coal-gas and water, the dry meter is a much more durable instrument than the wet.

Coal-gas, like water, has become a necessary of life. It is so, more especially in large towns. Its superiority over all other materials for producing light is acknowledged, and the general and persistent demand of the public for gas at a lower price, and of higher illuminating power, has induced gas companies again and again to lower its price; some to a point at which it is vain to expect profit so long as a loose system of measurement prevails, and one-fourth or one-fifth part of the whole quantity produced is allowed to go to waste, and is not paid for. Coal is becoming dearer; labor more expensive. And the question arises—How are dividends to be maintained or improved and the enormous capital sunk in gas properly protected? The coal cannot be made to produce more gas. Improvements and economy in its manufacture and distribution have nearly reached their limit. The pipes now are more solid than they used to be, while their increased size has enabled the companies to distribute their gas at a lower pressure. The joints, services, and fittings have been rendered much sounder and more perfect, so that, in gas-works which are properly managed, the actual loss by leakage is probably less than five per cent. And it is daily becoming more apparent that, if gas is to be produced at a remunerative rate, the present loose system of measurement must cease, and imperfect meters must give place to others which are reliable.

Mr. Alex. McIvor said they were all indebted to Mr. Glover for his able paper, and he had no doubt scientific men would admit that he had done them service, as well as the proprietors and managers of gas-works, in drawing attention to the subject of gas measurement. It had hitherto been a matter of great difficulty to find the means of accurately measuring gas, and this was only to be arrived at by the most delicate and carefully constructed apparatus. It must be admitted that great success had attended Mr. Glover's labors, for he had given a degree of accuracy and precision to the art of gas measuring which was previously unknown. The gasometers previously in use for testing meters were most imperfect and unsatisfactory, and presented a great many difficulties to gas managers. He had been shown by one manager a gasometer which he employed for this purpose, consisting simply of a bell suspended by a string over a pully. It was painted green, and when pulled out of the water it was covered with wet. It was unnecessary to point out how imperfect such a measuring instrument as that must be. It was to be regretted that many gas managers were but slightly acquainted with the nature of the process they carried on. Until they got suitable instruments, however, it could in no case be expected that they would do the work properly. The perfection to which the art of gas making and distribution was now brought reflected great credit on the country, and the importance of the manufacture

might be estimated by the fact that the consumption of gas in this kingdom amounted to £6,000,000 sterling annually.

Mr. Chaney said, as an officer of the Exchequer, he begged to thank Mr. Glover for his valuable paper. He wished at the same time to remind the meeting how much they were indebted to Professor Airey, whose name had been so prominently mentioned in the paper, for his labors on this subject. He had devoted much of his valuable time, for a period of thirty years, to the restoration and preservation of our standard weights and measures. They were also indebted to Mr. George Lowe, a famous gas engineer, for the introduction of the decimal system in gas measurement; and to Dr. Frankland, for his valuable investigations into the chemical and physical constitution of gas.

Mr. E. H. Thorman regretted that no manufacturer of wet meters had risen in their defence. He could not quite agree with the sweeping condemnation that had been passed upon those instruments. It was a long time before he became a convert to dry meters. He knew that the public would now, if possible, have dry meters, but he thought the complaints against wet meters were more than experience and practice justified. He believed that the bad cases of error that had been brought forward were quite exceptional, and he regards the wet meter as being very beautiful in its mechanical operation, and in every way worthy of the support of the gas companies.

Mr. C. F. T. Young considered that the defects of the wet meter had not been dwelt upon too strongly, as they immediately became manifest on inspecting one which had been a long time in use. There was a constant antagonism going on between the materials—iron and brass—of which the mechanical portion of the instrument was formed, and the water in which it worked, and destruction of the parts necessarily ensued. When they reflected upon the fact that so small a difference of level in the water as a quarter of an inch very materially affected the discharge of the gas from the meter, it would be seen how important it was, both to the consumer and the manufacturer, that an instrument not liable to such imperfections should be employed. He had heard it asserted by persons well informed on the subject, that wet meters had even been found to register incorrectly to the extent of 60 per cent. In the cases of 36 meters, taken indiscriminately, the register was found to be invariably incorrect, being in some cases against the consumer, and in others against the gas company. The dry meter certainly removed many of the objections which attached to the wet meter, and which were inherent to the principle on which it was constructed, and in his opinion the former was certainly much to be preferred.

Mr. F. W. Hartley said he stood there as an impartial individual, inasmuch as he was interested in the manufacture of both wet and dry meters. He admitted the truth of Mr. Glover's observations, but with some limitation. They were led to believe that the wet meter as now made was liable to grave and serious errors, both against the manufacturer and the consumer. He thought that could hardly be the case. The tilting of the meter in the way described by Mr. Glover could

hardly be carried on to any considerable extent without being detected by the inspecting officer of the company, on the one hand, or by the consumer on the other. The variation in the level of the water was permitted to the extent of 5 per cent.—2 per cent. against the consumer and 3 per cent. against the company. Protection was given to the consumer by a self-acting arrangement which shut off the supply as soon as the point was reached, which gave a register of 3 per cent. in favor of the company. He had inspected many hundreds of wet meters, but had never found such a variation as had been mentioned in the paper. As to the question of pressure, he denied that it had any effect upon the registration of the meter unless in connexion with increased speed of the measuring wheel. This, indeed, he had tested, for some years ago he had occasion to make experiments on this point, and he found that working a meter at something like one-tenth of its speed, and trying it up to five times the proper speed, only effected a variation of two to three per cent. Evaporation was an objection which told most against the wet meter, and was one on which its opponents dwelt very strongly, and there certainly was inconvenience from this at times. It was stated that the combination of different metals introduced into wet meters tended to rapid destruction; but they had practical evidence of the long duration of these meters. If there was that violent galvanic action which had been referred to, the meters would long since have been destroyed, and would have gone out of use, because the public would have found them not durable. He therefore thought they were justified in assuming that the wet meter was not so disadvantageous as it had been represented to be. Mr. Glover was mistaken in supposing that all gas-holders were measured by the transferrer previous to the passing of the Sales of Gas Act. He knew that at the present time there were gas-holders that had been graduated by the exact weight of water previously to the passing of that act; and nothing could be more accurate. There was less difference between them and the Exchequer standards than was permitted by the Act. He had nothing to say against the dry meter, but he believed that both that and the wet instrument were capable, if fairly used, of doing equal justice to the consumer and the company. If a wet meter were tilted in an unfair manner, they could not expect it to register correctly. It was as absurd to expect this as to place a clock on a shelf out of level and expect the pendulum to act.

Mr. Defries, as a manufacturer of meters with an angular motion, justified that form of construction, on the ground that it did not carry condensation, but threw off the condensed matter, and deposited it at the base of the meter, where it could always be drawn off without disturbing the meter itself. The notion that the leather of the diaphragm was injuriously affected by the action of the gas upon it was, he said, entirely erroneous.

Mr. Bishop, speaking only in the character of a gas consumer, expressed himself decidedly in favor of the dry meter.

The Chairman would now ask the meeting to accord their thanks to Mr. Glover for the very interesting paper he had read, and in doing

so he would for a moment consider the position in which this question had been placed before them. He took exception to one or two remarks made in the paper: First, as to the duty of the government in matters of this kind; and, in the next place, the statement that gas-works were not a nuisance to neighborhoods in which they were placed. As to the duty of the government, he dissented entirely from the view that it was the function of government to interfere with manufacturers of any kind, whether gas-meters or anything else. It devolved upon the consumer to look after his own interests and to employ that meter which he believed to be most just, both to himself and to the gas company.

Mr. Glover explained that he had not advocated that the government should interfere with manufacture, but should merely give every facility for the production of gas, as conducing to the public welfare. He entirely concurred in the views expressed by the Chairman as to the importance of the non-interference of government with trade or manufacture.

The Chairman, having quoted the paragraph of the paper which had prompted his remark, went on to say, he did not hold it was the duty of the government to interfere with manufactures in any way, and he did not know how they could "protect or encourage" without some sort of interference. He believed the real interests of commerce and of the progress of invention in this country were dependent upon the fullest and most unfettered employment of ingenuity and capital, and that government protection or interference of any kind was an evil. As regarded gas-works, he could not agree that it was desirable they should be placed in the centres of great towns. True, the recent accident which occurred at one of these works might have been prevented by proper precautions, but was there any accident which might not have been prevented by due and proper care? The question was, Were not gas-works subject to special kinds of accidents, and in the present day ought such elements of danger to be placed in the centres of large populations? He contended that the sooner such evils could be removed, without injustice to those who had invested their capital in them, the better. The paper opened the question as to which was the best instrument for measuring gas as it was delivered from the mains for the use of the consumer. He thought the relative merits of the wet and dry meter depended upon this, Which of the two instruments was composed of the most durable materials? In the one case, they have metallic mechanism working in water impregnated with ammonia, while the other meter was dependent upon the durability and elasticity of the leather diaphragm. It appeared to him, taking the facts as they stood on both sides, looking also at what had fallen from the speaker, who was a manufacturer of both kinds of meters, and judging from experience, the evidence seemed certainly to be in favor of the dry meter, as opposed to the wet, which required a very large amount of attention to secure accurate working. Without condemning the wet meter, which was certainly a most ingenious instrument, he thought that when they looked at the admirable contrivances

and beautiful workmanship which were introduced into the dry meters on the table before them, they must incline to the opinion that more permanent accuracy could be obtained by the latter instrument. He was sure they would feel that they were much indebted to Mr. Glover for the manner in which he had brought this subject under the notice of the Society, and he begged to propose a cordial vote of thanks to that gentleman for his paper.

The vote of thanks was unanimously passed.

Mr. Glover, in acknowledging the compliment, observed that he thought nothing had been said in the discussion to invalidate the statements made in his paper.

Measures of Length, Capacity, and Weight.

Among the important acts passed at the last session of the Congress of the United States, there are three to which we wish to call the attention of our readers, in consequence of their great importance to the commerce and industry of our country. One of the earliest efforts of our government, after the establishment of our independence, was to draw closer the bonds of union between different civilized nations, by bringing about the use of common standards for all purposes of international intercourse. The attention of Mr. Jefferson, as Secretary of State, was, at an early period, directed to this object, and it may be said that from that time to this our government has never lost sight of this object, and never ceased to labor for its accomplishment. The bold and successful adoption, by the French revolutionary government, of a new and rational set of measures, which were all connected together, and subjected to the simple decimal system of division, although it appeared at first to increase the existing confusion by adding one more to the numerous systems in use, yet in reality first rendered uniformity practicable by presenting a system, which, although probably not the best possible in conception, was still far superior to any in use: and this movement has resulted in the gradual adoption of the metrical system by many of the European nations, and its legal recognition and toleration by almost all. Perhaps the reluctance to adopt this system in this country arose as much from the American tendency to the best possible, as to the fact that our chief intercourse was with England, which, with characteristic obstinacy, held out against any change of her onerous and absurd collection of standards. When, therefore, the English Parliament yielded and legalized, in the British dominions, the French metrical system, we, on this side of the Atlantic, were compelled to follow; because it has become evident that, whatever theoretical advantages other systems may have, the metrical system is the best one whose general adoption is possible. In view of this the United States Congress, at its last session, passed a series of Acts, the intention and result of which is to legalize the use of the French metrical system in this country, and to establish the ratios for the conversion of our ordinary standards into the French, and *vice versa*. We give these Acts in full, on account of their importance, and shall, in a

future number, give a series of tables for the conversion of one set into the other, which we hope our readers will find useful to them.

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JOINT RESOLUTION

To enable the Secretary of the Treasury to furnish to each State one set of the standard weights and measures of the metric system.

Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Treasury be, and he is hereby, authorized and directed to furnish to each State, to be delivered to the Governor thereof, one set of the standard weights and measures of the metric system for the use of the States, respectively.

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AN ACT

To authorize the use in post offices of weights of the denomination of grams.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Postmaster-General be, and he is hereby, authorized and directed to furnish to the post offices exchanging mails with foreign countries, and to such other offices as he shall think expedient, postal balances denominated in grams of the metric system; and, until otherwise provided by law, one-half ounce avoirdupois shall be deemed and taken for postal purposes as the equivalent of fifteen grams of the metric weights, and so adopted in progression; and the rates of postage shall be applied accordingly.

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AN ACT

To authorize the use of the metric system of weights and measures.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That from and after the passage of this Act it shall be lawful throughout the United States of America to employ the weights and measures of the metric system; and no contract or dealing, or pleading in any court, shall be deemed invalid or liable to objection because the weights or measures expressed or referred to therein are weights or measures of the metric system.

SEC. 2. *And be it further enacted*, That the tables in the schedule hereto annexed shall be recognised in the construction of contracts, and in all legal proceedings, as establishing, in terms of the weights and measures now in use in the United States, the equivalents of the weights and measures expressed therein in terms of the metric system; and said tables may be lawfully used for computing, determining, and expressing in customary weights and measures the weights and measures of the metric system.

Measures of Surface.

Metric denominations and values.		Equivalents in denominations in use.
Hectare..........	10,000 square meters.	2·471 acres.
Are................	100 square meters.	119·6 square yards.
Centare..........	1 square metre.	1550 square inches.

Measures of Capacity.

METRIC DENOMINATIONS AND VALUES.			EQUIVALENTS IN DENOMINATIONS IN USE.	
Names.	Number of liters.	Cubic measure.	Dry measure.	Liquid or wine measure.
Kiloliter, or stere	1000	1 cubic meter	1·308 cubic yards	264·17 gallons.
Hectoliter	100	$\frac{1}{10}$ of a cubic meter	2 bushels and 3·35 pecks	26·417 gallons.
Dekaliter	10	10 cubic decimeters	9·08 quarts	2·6417 gallons.
Liter	1	1 cubic decimeter	0·908 quart	1·0567 quart.
Deciliter	$\frac{1}{10}$	$\frac{1}{10}$ of a cubic decimeter	6·1022 cubic inches	0·845 gill.
Centiliter	$\frac{1}{100}$	10 cubic centimeters	0·6102 cubic inch	0·338 fluid ounce.
Milliliter	$\frac{1}{1000}$	1 cubic centimeter	0·061 cubic inch	0·27 fluid dram.

Measures of Length.

Metric denominations and values.		Equivalents in denominations in use.
Myriameter..........	10,000 meters.	6·2137 miles.
Kilometer............	1,000 meters.	0·62137 miles, or 3280 feet 10 inches.
Hectometer...........	100 meters.	328 feet 1 inch.
Dekameter............	10 meters.	393·7 inches.
Meter................	1 meter.	39·37 inches.
Decimeter............	$\frac{1}{10}$ of a meter.	3·937 inches.
Centimeter...........	$\frac{1}{100}$ of a meter.	0·3937 inch.
Millimeter...........	$\frac{1}{1000}$ of a meter.	0·0394 inch.

Weights.

METRIC DENOMINATIONS AND VALUES.			EQUIVALENTS IN DENOMINATIONS IN USE.
Names.	Number of grams.	Weight of what quantity of water at maximum density.	Avoirdupois wt.
Millier, or tonneau.	1,000,000	1 cubic meter..............	2204 6 pounds.
Quintal..............	100,000	1 hectoliter...............	220·46 pounds.
Myriagram............	10,000	10 liters..................	22·046 pounds.
Kilogram, or kilo,..	1,000	1 liter....................	2·2046 pounds.
Hectogram............	100	1 deciliter................	3·5274 ounces.
Dekagram.............	10	10 cubic centimeters	0·3527 ounce.
Gram	1	1 cubic centimeter.........	15·432 grains.
Decigram.............	$\frac{1}{10}$	$\frac{1}{10}$ of a cubic centimeter..	1·5432 grains.
Centigram	$\frac{1}{100}$	10 cubic millimeters.......	0·1543 grain.
Milligram............	$\frac{1}{1000}$	1 cubic millimeter.........	0·0154 grain.

Recent Progress in the History of proposed Substitutes for Gunpowder. By Prof. F. A. Abel, F.R.S., V. P. C. S., Chemist to the War Department.

From the London Chemical News, No. 344.

The changes which have been effected in the composition of gunpowder, since its first application as a propelling agent, have been limited to small variations in the proportions of its constituents. But the modifications which have from time to time been introduced into the details of manufacture, *e.g.*, the preparation of the ingredients, their incorporation, and the conversion of the mixture into compact masses (grains, &c.) of different size and density, have been sufficiently important and successful to secure the fulfillment by gunpowder, in a more or less efficient manner, of the very various requirements of military science and of different branches of industry.

The characteristics of gunpowder, as an explosive material of permanent character, the action of which is susceptible of great modifica-

tion, are mainly ascribable to the peculiar properties of the oxidizing agent—saltpetre. Frequent attempts have been made to replace this constituent of gunpowder by other nitrates, (such as those of sodium, lead, and barium ;) but, although materials suitable for blasting operations have been thus prepared, (such as soda-gunpowder, and barytic powder, or *poudre saxifragine*,) all mixutres of this class hitherto produced have exhibited important defects, when compared with gunpowder manufactured for propelling purposes.

The well-known oxidizing agent, chlorate of potash, which differs from saltpetre only in containing chlorine in the place of nitrogen, is far more energetic in its action upon oxidizable bodies than any of the nitrates. Thus, a mixture of chlorate of potash with charcoal alone deflagrates as violently as gunpowder, and is far more readily inflamed by percussion than the latter; while a mixture analogous to gunpowder, containing chlorate of potash in place of saltpetre, detonates violently when struck with moderate force, and acts far too destructively, on account of the rapidity of its explosion, to admit of its safe employment in fire-arms.

Many years ago, a mixture known as German, or white, gunpowder, and consisting of chlorate of potash, ferrocyanide of potassium, and sugar, was proposed and tried without success as a substitute for gunpowder; and since then many preparations of a similar character have been suggested for employment either as blasting and mining agents, or for use in shells, or even for all the purposes to which gunpowder is applied. The most promising of these, claimed as discoveries by Mr. Horsely and Dr. Ehrhardt, are mixtures of chlorate of potash with substances of permanent character and readily obtained, containing both carbon and hydrogen, such as tannic and gallic acids, and some kinds of resins. These mixtures are much less violently detonating than most of the explosive mixtures containing chlorate of potash, while, if well prepared, they are decidedly more powerful as explosives than gunpowder. For blasting purposes some of these mixtures probably possess decided advantages over ordinary blasting powder, and possibly they may also be susceptible of employment for sporting purposes; but they are not applicable to fire-arms used for war purposes, because, in order to ensure the requisite uniformity of action, the ingredients must be submitted to proper processes of incorporation, &c., such as are applied to the manufacture of gunpowder; and this treatment would render the mixtures far more violent, and consequently destructive, in their action upon fire-arms, than if used in the form of crude mixtures.

A comparatively very safe application of chlorate of potash to the production of a substitute for gunpowder was made about six years ago by a German chemical manufacturer, M. Hochstädter. Unsized (blotting) paper was thoroughly soaked in, and coated with, a thin paste consisting of chlorate of potash, finely divided charcoal, a small quantity of sulphide of antimony, and a little starch, gum, or some similar binding material, water being used as the solvent and mixing agent. The paper was rolled up very compactly and dried in that form.

In this manner, very firm rolls of an explosive material are obtained, which burns with considerable violence in open air, and the propelling effect of which, in small arms, has occasionally been found greater than that of a corresponding charge of rifle powder. Moreover, the material, if submitted in small portions to violent percussion, exhibits but little tendency to detonation. But as no reliance can be placed on a sufficient uniformity of action, in a fire-arm, of these explosive rolls, this alone sufficed to prevent their competing with powder. The same description of explosive preparation, differing only from that of M. Hochstädter in a trifling modification of its composition, which is certainly not likely to lead to its greater success, has recently been brought forward in this country by M. Reichen and Mr. Melland.

One or two other much cruder explosive preparations, containing chlorate of potash, alone or in conjunction with saltpetre, have met with some application to blasting purposes. One of these consisted of spent tan, in small fragments, which was saturated with the oxidizing agent, and afterwards dusted over with sulphur. When flame or a red-hot iron is applied to this preparation, it deflagrates very slowly and imperfectly; but when employed in blast holes, where it is confined within a small space, it develops sufficient explosive force to do good work. In addition to comparative cheapness, the great advantage of safety was claimed for this material by its inventor, a claim which was substantiated by the partial destruction by fire, on two occasions, of a manufactory of the substance near Plymouth, without the occurrence of an explosion.

The accidental explosions of gunpowder which are occasionally heard of, occur, in most instances, at the manufactories, and in the course of some operation (especially that of incorporation) to which the explosive mixture is submitted. The only means of guarding against, or reducing as much as possible, the liability to the occurrence of these accidents, consist in the strictest attention to the precautionary measures and regulations, which experience has proved to be essential to safety, and which, in spite of the strictest supervision, are unquestionably sometimes overlooked or imperfectly carried out by workmen. Explosions of gunpowder, generally of a serious character, do occur, however, though very rarely, during the transport of the material, or in magazines where it is stored. The great explosion of a gunpowder magazine at Erith in September, 1864, specially directed the attention of government and the public generally to the necessity of adopting measures for reducing, as much as possible, the risk of occurrences of such disastrous accidents. Hence, much interest has recently been excited by a well-known method of rendering gunpowder less dangerous in its character, which has been brought prominently before the public by Mr. Gale, and which consists of diluting powder, or separating its grains from each other, by means of a finely powdered non-explosive substance. Attempts have several times been made in past years to apply to practical purposes the obvious fact, of which nobody acquainted with the nature of gunpowder could be ignorant, that, by interposing between the grains of powder a sufficient quantity of a finely

divided material, which offers great resistance to the transmission of heat, the ignition of separate grains of the entire mass may be accomplished without risk of inflaming contiguous grains. In 1835, Piobert made a series of experiments with the view to apply this fact practically to reduce the explosiveness of gunpowder, and similar experiments of an extensive character were carried on by a Russian chemist, Fadéiff, between 1841 and 1844. These experimenters found that the object in view might be attained by diluting gunpowder with any one of its components; they also employed very fine sand, (a substance closely allied in its physical characters to the powdered glass which Mr. Gale now proposes to use;) but the preference appears to have been given to a particular form of carbon. It was not attempted altogether to prevent the burning of a mass of gunpowder when a spark or flame reached any portion, but to reduce the rapidity of combustion so greatly as to prevent the occurrence of a violent explosion. No more than this is accomplished by the employment of powdered glass in the proportions directed by Mr. Gale. Indeed, as the quantity of diluent required to give to different kinds of gunpowder the character of equally slow burning materials, increases with the explosiveness of the particular powder and with the size of its grain, the proportion of powdered glass with which the gunpowder employed in rifled cannon would have to be mixed to render it only slow burning, would be about double the quantity required for almost altogether preventing the ignition of fine grain powder, or of the comparatively weak blasting powder with which Mr. Gale's public experiments appear generally to have been instituted. Although a sufficient dilution of gunpowder may secure such comparative safety to the neighborhoods of large magazines, or to the crews of merchant vessels in which gunpowder (for blasting purposes, &c.) is transported, as to compensate fully for the inconvenience attending the great increase of volume of the powder, there is no doubt that such a treatment of gunpowder actually issued for military and naval service would be attended by more than one serious obstacle—such as the tendency of the powder, unless very largely diluted, to separate from the glass, during transport by land or sea, to so considerable an extent as very greatly to diminish the degree of security originally aimed at; the very great addition which would have to be made to the arrangements for carrying the necessary ammunition in active service; the necessity for introducing, in the field or on board ship, the operations of separating the powder from the glass and transferring it to cartridges and shells, (which, whatever sifting and other arrangements were adopted, would be time-taking and very dangerous,) instead of preserving the ammunition ready for immediate use: and, above all, the incalculable mischief which would inevitably result from the establishment, in the minds of the soldier and sailor, of an erroneous feeling of security in dealing with gunpowder, which, however harmless it may for a time be rendered, must finally be handled by the men in its explosive form. The extremely rare occurrence of accidents with gunpowder, on board ship or in active land service, is mainly due to the strictest enforcement of precaution-

ary regulations, some of which may appear at first sight exaggerated or almost absurd, but which combine to maintain a consciousness of danger and a consequent vigilance indispensable to safety.

One of the most remarkable materials recently employed to replace gunpowder as a destructive agent is nitro-glycerine. This substance was discovered by Sobrero in 1847, and is produced by adding glycerine in successive small quantities to a mixture of one volume of nitric acid of sp. gr. 1·43, and two volumes of sulphuric acid of sp. gr. 1·83. The acid is cooled artificially during the addition of glycerine, and the mixture is afterwards poured into water, when an amber-colored, oily fluid separates, which is insoluble in water, and possesses no odor, but has a sweet, pungent flavor, and is very poisonous, a minute quantity placed upon the tongue producing violent headache which lasts for several hours.

The liquid has a sp. gr. of 1·6, and solidifies at about 5° C., (40° Fahr.) If flame is applied, nitro-glycerine simply burns, and if placed upon paper or metal, and held over a source of heat, it explodes feebly after a short time, burning with a smoky flame. If paper moistened with it be sharply struck, a somewhat violent detonation is produced. Alfred Noble, a Swedish engineer, was the first to attempt the application of nitro-glycerine as an explosive agent, in 1864.

Some experiments were, in the first instance, made with gunpowder, the grains of which had been saturated with nitro-glycerine. This powder burnt much as usual, but with a brighter flame in open air. When confined in shells or blast holes, greater effects were, however, produced with it than with ordinary gunpowder; its destructive action is described as having been from three to six times greater than that of powder. The liquid could not be employed as a blasting agent in the ordinary manner, as the application of flame to it from a common fuze would not cause it to explode. But Mr. Noble has succeeded, by employing a special description of fuze, in applying the liquid alone as a very powerful destructive agent. The charge of nitro-glycerine having been introduced, in a suitable case, into the blast hole, a fuze, to the extremity of which is attached a small quantity of gunpowder, is fixed immediately over the liquid. The concussion produced by the exploding powder upon the ignition of the fuze effects the explosion of the nitro-glycerine.

The destructive action of this material is estimated, by those who have made experiments in Sweden and Germany, as about ten times that of an equal weight of gunpowder. Therefore, although its cost is about seven times that of blasting powder, its use is stated to be attended with great economy, more especially in hard rocks, a considerable saving being effected by its means in the labor of the miners, and in the time occupied in performing a given amount of work, as much fewer and smaller blast holes are required than when gunpowder is employed. The material appears to have recently received considerable application in some parts of Germany and in Sweden; but in England its employment has been confined to one set of experiments instituted in Cornwall last summer, upon which occasion a wrought

iron block, weighing about three hundred-weight, was rent into fragments by the explosion of a charge of less than one ounce of nitro-glycerine placed in a central cavity.

Nitro-glycerine appears, therefore, to possess very important advantages over gunpowder as a blasting and destructive agent, but the attempts to introduce it as a substitute for gunpowder have already been attended by most disastrous results, ascribable in part to some of its properties and the evident instability of the commercial product, but principally to the thoughtlessness of those interested in its application, who appear to have been induced, either by undue confidence in its permanence and comparative safety, or from less excusable motives, to leave the masters of ships or others who had to deal with the transport of the material, in ignorance of its dangerous character.

The precise causes of the fearful explosions of nitro-glycerine which occurred at Aspinwall and San Francisco will, in all probability, never be ascertained; but they are likely to have been due, at any rate, indirectly to the spontaneous decomposition of the substance, induced or accelerated by the elevated temperature of the atmosphere in those parts of the ship where it was stored. Instances are on record in which the violent rupture of closed vessels containing commercial nitro-glycerine has been occasioned by the accumulation of gases generated by its gradual decomposition; and it is, at any rate, not improbable that a similar result, favored by the warmth of the atmosphere, and eventually determined by some accidental agitation of the contents of the package of nitro-glycerine, was the cause of those lamentable accidents. The great difficulties attending the purification of nitro-glycerine upon a practical scale, and the uncertainty, as regards stability, of the material even when purified, (leaving out of consideration its very poisonous character and its extreme sensitiveness to explosion by percussion when in the solid form,) appear to present insurmountable obstacles to its safe application as a substitute for gunpowder.

(To be continued.)

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, September 19*th*, 1866.

The meeting was called to order with the Vice-President, Prof. Fairman Rogers, in the chair.

The minutes of the last meeting were read and approved.

The Board of Managers presented their minutes and reported the following donations to the Library:

From the Royal Astronomical Society, the Royal Geographical Society, the Society of Arts, the Chemical Society, the Statistical Society, and the Institute of Actuaries, London, England; Thomas Oldham, Superintendent of the Geological Survey of India, Calcutta, India; la Sociétié d'Encouragement pour l'Industrié Nationale, l'Ecoles des Mines,

l'Academie des Sciences, Paris, and la Sociétié Industrielle, Mulhouse, France; the Oesterreichischen Ingenieur-Veriens and the K. K. Geologischen Reichsanstalt, Vienna, Austria; Major L. A. Huguet-Latour, Montreal, Canada; the Commissioner of Patents, the Commissioner of Agriculture, and Hon. Edgar Cowan, U. S. Senate, Washington, D. C.; the Ohio Mechanics' Institute, Cincinnati, Ohio; the Managers of the State Lunatic Asylum, Utica, New York; and Wm. Milnor Roberts, Esq., Frederick Fraley, Esq., and the American Philosophical Society, Philadelphia.

The various Standing Committees reported their minutes, and the Special Committee on Experiments in Steam Expansion reported progress.

The following resolution was then proposed by Mr. George Erety, and was duly seconded and carried:

Resolved, That the President shall appoint a committee of five members of the Institute, whose duty it shall be to obtain and collect information and facts relative to the early organization of the Franklin Institute, and the causes that led thereto, the state of the American mechanic arts at the period of said organization, the influence of the Institute thereon, and the progress made in said arts, and the sciences connected therewith, since that time. With such matters in relation to, and the present state of the Institute, as in their judgment may be useful. And that said Committee shall be authorized to have prepared for publication the information and facts on the subject so obtained and collected.

The following named gentlemen were appointed by the President of the Institute, in accordance with the above resolution: Samuel V. Merrick, Chairman; Fred. Fraley, John C. Cresson, John F. Frazer, George Erety.

Secretary's Report.

ENGINEERING WORKS, &c.—The Sand Patch tunnel on the Pittsburgh and Connelsville Railroad is at last cut through. Its total length is 4750 feet, being 1000 feet more than the long tunnel on the Pennsylvania Central Railroad through the Alleghanies between Altoona and Cresson. It is intended for a double track, and is 22 feet wide by 19 feet in height.

The sewage pumps at Crossness.—In the new system of drainage applied to London, a large amount of the sewage matter collects at a level, requiring the use of pumps to remove it. To meet this demand a system of engines, &c., have been established at Crossness, by which this matter is raised 19 feet 6 inches, and thrown into a reservoir constructed for its reception. This reservoir covers an area of 6½ acres, is 14 feet deep, and has a capacity of 24,000,000 gallons. It is arched over with brick-work, supported on 644 piers, and is covered with earth and sod.

It is usual to discharge this reservoir into the river about half an hour before high tide, but during heavy rains it is filled and emptied four times in the 24 hours.

The engines are 4 in number, each working 8 pumps, which are of the usual plunger construction; their aggregate capacity amounts to 29,523 gallons per minute. The minimum amount raised in 24 hours is 38,000,000 gallons, the maximum 100,000,000 gallons.

Traction engines for common roads have been put successfully in operation in two places. One of these, constructed by Dübs & Co., of Glasgow, for use in Syria, on the road between Damascus and Beyrout, was tried near the place of its manufacture and attained an average speed of 4½ miles per hour, the maximum being 6 miles, with a load of 10 tons.

A gold medal of the first class was also awarded to Albert & Co., of Liancourt, by the Minister of Public Works, for a traction engine drawing a load of 5 tons with a maximum speed of 5 miles per hour and an average of three and a half.

PHYSICS, Light.—Improvements in lime-lights, by Robert Grant, 246 Canal Street, New York.

All who have used the lime-light for a long time are well aware of the inconveniences which attend the employment of india rubber gas-bags as reservoirs for one or both of the gases. Their rapid deterioration, liabily to injury in transportation, whether full or empty, leakage, unwieldiness, and cost, are all drawbacks fully realized by all concerned. The advantages of the new plan, as regards the matter of reservoirs, will then be clear on simple inspection. In this, iron cylindrical reservoirs, 9 inches in diameter by 30 in length, and having therefore a capacity of about one cubic foot, are made so strong as to bear with perfect safety a pressure of 30 atmospheres, but yet weigh only 26 pounds. These are charged by means of condensing pumps, with the gases required up to the pressure named, when each will contain 30 cubic feet, or about 224 gallons of gas—as much as would *fill* 6 *of the large* 30 *by* 40 *inch gas-bags* commonly employed.

Two of these reservoirs, one charged with oxygen and one with burning gas, can be easily carried by a boy, and represent in efficiency a large cart-load of apparatus on the old plan, namely, 12 gas-bags, 2 sets of press-boards, and some 600 pounds in iron weights.

These reservoirs may be directly connected with the jet, which must be then regulated by the plug-valves attached to the reservoirs.

The same inventor, however, supplies a regulator, which you here see attached to this reservoir, which equalizes the pressure beyond it, so that the gases may be controlled or shut off from the light without danger of bursting the connecting india rubber tubes.

While the pressure in the reservoir is at about 30 atmospheres you see by this water-gauge that, beyond the regulator, it amounts only to 12 inches of water, or the $\frac{1}{30}$th of an atmosphere, and is little changed by altering the flow of gas at the jet or shutting it off entirely.

These reservoirs are furnished at a price regulated by their capacity in the sense of strength, (since all are of one size,) this being one dollar per cubic foot. Thus a reservoir capable of bearing a pressure of 30 atmospheres, and therefore of holding 30 cubic feet, costs $30, one bearing 20 atmospheres, and therefore holding 20 cubic feet, $20, &c.

The gases are supplied at the rate of 30 cents for oxygen and 3 cents for burning gas per cubic foot, charged into the reservoirs.

In the case of oxygen this is about double the cost of the chlorate of potash needed to make it.

In reservoirs of similar form, but of stronger construction, nitrous oxide and carbonic acid are furnished in the liquid form. Thus, at a lecture delivered last Spring in the Brooklyn Academy of Music, by Dr. Doremus, Mr. Grant supplied 40 cubic feet of liquid carbonic acid for certain of the experiments.

The next point of improvement is in the form of the jet at which the mixed gases are burned. This is made by hammering in the end of a tapering copper tube, and then boring a hole in the flattened end, so that the vertical section of the jet shall be as is represented in the cut.

The different gases enter this tube at its lower end and are lit where they escape from the upper end. By the simple means above indicated all snapping of the jet from the running back of the flame into it, and consequent extinction of the light, are avoided, even when jets of extraordinary size are employed. Large jets, in fact, cannot be operated with the mixed gases except in this way, while with this form jets have been used of immense size. Thus, at the lecture before mentioned, a *cavalry sabre was burned up* in one of these.

The reason of the efficiency attained by this form seems to be, that while in a simple cylindrical or conical jet, the friction against the sides establishes a rolling motion in the gas particles, whereby the velocity of the issuing jet is diminished at its surface, thus allowing the fire to run back and ignite the mixture inside; in this case all such action is prevented, and the maximum velocity is maintained in all parts of the issuing stream.

It has been pointed out by Tyndall that the non-explosion of the gases in the jet, is simply secured by forcing them out faster than the flame will run back, and the plan now before you is an illustration of this theory. Important improvements often demand a bold departure from received methods, and it is curious to notice in the present case that what has been previously sought by the use of many narrow passages, wire gauze diaphragms and other like means, is here attained by discarding them all. By the use of jets constructed on this plan, which may be of a size heretofore unattainable, and reservoirs such as above described of very unusual practical capacity, an amount of light is generated so great as to open new fields for its application, and to enable it, for many purposes, to take the place of the electric light in fields where heretofore this last defied competition. Such applications are the lighting of large areas for public assemblies in the open air, either for purposes of debate or amusement; the illumination of extensive engineering structures during night-work, especially in connexion with the repair of railroads, bridges, &c., where delay involves interruption of traffic and great consequent loss; lastly, various applications in connexion with military affairs. No better means can be taken to give a clear impression of the efficiency of these lights in all

the above uses, to which they have been successfully applied, than a description of their operation during the siege of Fort Wagner on James' Island, opposite Charleston, where they were employed with the happiest effect.

The front of Fort Wagner, toward which the advances of the United States forces were made, was about 700 yards in length, while the approaching saps were confined to a narrow strip of solid land about 50 yards across, the rest of the fort being covered by a swamp on one side and the ocean on the other. For this reason, when the head of the sap had been pushed to within 250 yards of the fort, further advance was rendered impossible, because the zig-zags would be enfiladed from one side or another by the guns at the extremities of the fort.

It was under these conditions, no advance having been made for several days, and the loss in the trenches being very heavy, that the calcium lights were first tried. Two of these, with jets $\frac{1}{18}$ inch in diameter, burning about 14 cubic feet of gas per hour, were set up at the extreme left of the second parallel, about 750 yards distant from the fort. These jets were supplied from large reservoirs 15 inches by 8 feet, each capable of holding 250 cubic feet. Both the gases were made on the island in a laboratory established for the purpose, where a detail of 20 soldiers and 12 negroes was constantly employed in the manufacture and compression of the gases for use in various ways connected with the military operations at this point, such as the prevention of blockade running at night, of sending supplies and troops to Fort Sumpter, &c.

The two lights above mentioned were so arranged with parabolic mirrors as to throw sectors of light, one over one half of the fort and the other over the remainder, the field of light being sharply cut by a diaphragm so as not to reach below the edge of the parapet. The effect of this was to make every motion, and each figure on the rebel works, perfectly clear to those in the trenches, while the space below, from the ditch of the fort to the saps and parallels, was hid in impenetrable darkness.

The Union riflemen and sharp-shooters, in fact, were able to leave the protection of their works with impunity, while, on the contrary, all the gunners in the fort were exposed to a deadly fire. The consequence was that, within twenty minutes after starting the lights, the fort, from which a constant fusilade had been kept up ever since the darkness set in, was *absolutely silenced*, and remained so during the night.

Advantage was, of course, taken of this condition to push forward the sap, and by the end of the second night such progress had been made that the eastern angle of the fort was entered, and the work becoming no longer tenable, was abandoned by its garrison. Of course, every available gun was brought to bear upon the lights from the neighboring batteries, but their dazzling points seem to have been very hard objects to aim at, for though some of the reservoirs were hit by fragments of shell, and still bear the dints so inflicted, the apparatus was never seriously damaged.

Lime-lights for locomotives.—In connexion with the above we will here note the fact that many locomotives on the Pennsylvania Central Railroad have, during the past year, been using in their front lamps an apparatus in which light is obtained by driving a jet of gas, carried in one of these reservoirs, mixed with air supplied by a small pump worked by the engine and heated in a small coil of tube passing over some minute burners before it issues from the jet. We are not yet informed of the details and precise results of this process, but hope to supply full information by the next meeting of this Institute.

In the *London Mechanics' Magazine*, for June 8th, we find an editorial on the subject of car lighting, in which it is stated that the process of lighting with gas, carried in flexible bags, has been found very inconvenient and unsatisfactory in its results, and that some of the larger companies have therefore made experiments on the practicability of using iron reservoirs and storing the gas under pressure. These, it appears, have culminated in a plan by Mr. Wm. Dalzeil, who uses iron cylinders of 18 inches diameter by 9 feet 6 inches in length, and pumps in the gas up to a pressure of 120 pounds per square inch, or eight atmospheres.

To those who, for the last eight years, have been riding between this city and New York, not to mention most of our other large roads, in cars lit in exactly this way, it will seem that some kind friend might have saved these companies the expense of preliminary experiments.

A new form of magnesium lamp has been invented and applied by Mr. H. Larkin, and was exhibited at the late meeting of the British Association, when two of these lamps were employed to light a large tent, which had been decorated with flowers, shrubs, rockwork, fountains, &c.

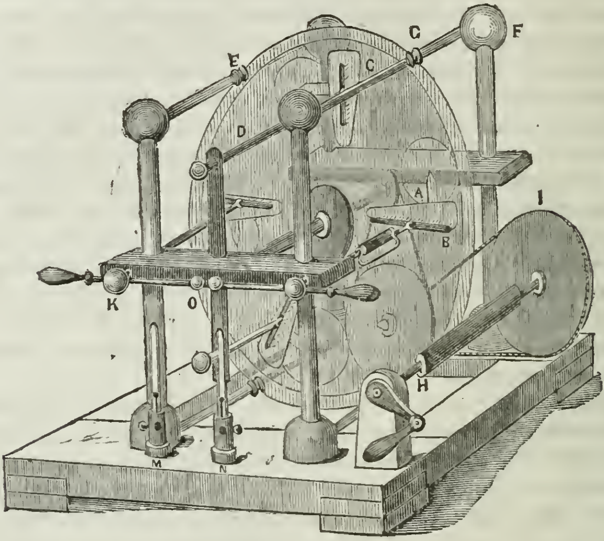
In this apparatus the magnesium is employed in the form of a fine powder in place of wire or ribbon, as in previous instruments. This powder is mingled with a little fine sand to facilitate its flow, and is then fed from a hopper, through a regulating-valve, into a tube or nozzle to which is admitted a current of burning-gas, so that the powder escapes from the end mingled with enough gas to keep up a small flame. This gas jet may be first lit and allowed to burn, and then the magnesium turned on and off whenever convenient. The addition of a little nitrate of strontium to the powder is said to relieve the painful blueness of the pure magnesium light.

Micro-photography.—Under the present head we would call attention to the very interesting papers on the above subject by Major J. J. Woodward in the September number of the *Philadelphia Photographer* and *Silliman's Journal.* On a future occasion I hope, however, to exhibit to you, in an advantageous manner, specimens of the work produced by this gentleman, which, as you are probably aware, introduces a new era in this branch of scientific application.

PHYSICS, Electricity.—The Holtz electrical machine was then exhibited and described. This is of great interest, both on account of its entire novelty (the instrument in question being the first seen in this country, and even the first of large size manufactured in Paris,)

and by reason of the new applications of electrical facts which it involves, and lastly by reason of its very great efficiency.

The action of this machine will be best understood if we first describe fully the accompanying cut which represents it.



The most conspicuous part of this instrument is its pair of glass plates. These are arranged in close proximity to each other, and are both made of very thin plate-glass varnished with shellac. The nearest of these plates, as shown in the cut, is a little the smaller and is perfectly plain, supported on an axle which passes through a large central hole in the other plate and is put in motion by a winch H and pully wheels I, &c. The further and larger plate is supported in the grooved balls E, G, &c., on the horizontal glass rods, and has, beside the central hole, four others, of a circular shape, as indicated in the cut. At one side of each opening is pasted a strip of paper with a point of card projecting into the opening. The rotation of the movable plate is in a direction from point to base of these card projections. Opposite to each of the paper strips, but with the revolving plate, (be it remembered,) between, is a brass comb or collector B, C, &c., supported in the cross-piece of vulcanite K D by appropriate brass rods, having balls at their opposite ends. Sliding-rods passing through two of these balls enable us to vary the distance of the poles and so to modify the discharge. Sliding brass conductors, M N, may be brought in contact with these poles, and so, by the binding screws at their base, enable us to make connexion with various pieces of apparatus.

One of the brass rods is separated by a portion of vulcanite, but may be united electrically by a wire staple, as shown in the cut near B.

The four brass collectors may be united in various ways by bent

wires for different effects, but we will at present only describe one of these.

The conductor B being insulated by the removal of the wire staple, is connected with the opposite one by a bent wire, and thus the ball to the left becomes the pole for these two.

The upper and lower balls are in turn united by a wire which rests on the right-hand ball, through which the sliding rod passes, and this thus becomes the pole for this pair of conductors.

The movable plate being started in rotation by the winch and pulley-wheel, one of the paper strips is charged by touching it with a piece of vulcanite, excited by a stroke over a rabbit skin, and at once the whole machine is in activity, giving sparks of great volume and intensity, which may be continued for an indefinite time without further charging.

There are no rubbing parts in the machine, the whole effect being developed by induction or the disturbance produced in the electric fluids by the repulsion of like and attraction of unlike kinds. And yet, strange to say, this friction-avoiding machine exhibits all the effects belonging to what is commonly called frictional electricity.

It will pour a torrent of sparks between its terminal balls too rapidly to admit of their being counted and each giving a report like that of a torpedo; or, by a different adjustment, will furnish a continuous jet of electric fire, seeming to pass without change or pause in a tassel of purple light trimmed with golden beads and emitting a hissing sound like that of escaping steam. Those beautiful instruments, the Geissler tubes, are operated by this machine with the most excellent effect. The theory of this machine seems to be as follows: Suppose one of the paper strips, C, to be negatively excited by contact with the vulcanite, it will draw positive electricity from the opposite brass conductor, D, and cause this fluid to spread over the nearer side of the movable plate. The plate then turning in the direction C A, before mentioned, this positively charged portion will come opposite the next opening in the fixed plate, and the repulsive action of the positive charge, just mentioned, will cause other positive fluid to be repelled from the further side of the revolving plate and to enter the point projecting from the paper, A, at that part, so charging this strip positively.

This positively charged strip of paper will then act upon the revolving disk exactly as the negatively charged one did before, but, of course, in the opposite sense, *i. e.*, it will attract negative electricity from the conductor B, and excite negatively the outer side of the revolving plate as it passes this point, by which means negative electricity will be carried to the next strip of paper, and so on alternately around the plate.

This whole description might, of course, be duplicated in the sense of stating in every case, where positive fluid goes one way, that negative goes in the opposite, and *vice versa*, but this would simply confuse the explanation without in any way effecting its bearing.

To obtain condensed and bright sparks, we attach a glass tube, closed at one end and lined internally with tin-foil, so that its lining is in connexion with one of the brass conductors.

Printing Telegraph.—We see announced in the *London Mechan-*

ics' Magazine for July, page 21, some improvements in the Bonelli telegraph, by which the number of wires needed was reduced from five to one. This telegraph transmits its messages from type which are set up and passed under a metallic point, by which a current is transmitted and a fac-simile produced at the distant place by electric decomposition in a strip of prepared paper.

In a subsequent number of the same magazine, page 59, these improvements are claimed by Mr. J. H. Simpson. The great drawback in the use of all these electro-chemical telegraphs has been the cost of batteries needed to work them, and we do not see that either of the plans will reduce this within the required limits.

Mr. Wild's improvements in magneto-electric machines have been purchased by the Alliance Company of France, and we may therefore soon hope to see them practically applied, and the cost of these instruments so reduced as to render their general use and application possible.

CHEMISTRY.—A test for gilt articles, to distinguish them from those which are simply made of a gold colored bronze, is announced by Weber. It consists in the application of bichloride (the common chloride) of copper in solution, which makes a brown stain on other articles but does not affect those which are gilt. This statement I have verified with articles known to be gilt and with several varieties of gold colored alloys.

The oxidation of crude soda liquors may be effected in a rapid and economical manner, according to a plan proposed by James Hargraves, if the solution to be treated be placed in an iron cylinder having a false bottom, pierced with many holes, into the space beneath which runs a vertical tube expanded at its upper end into a funnel. Into this funnel, high pressure steam is run by a pipe, and this carries down a large quantity of air below the false bottom, and this air, heated by, and in presence of, the steam, exerts a powerful oxidizing action as it rises through the liquid in numerous bubbles from the perforation of the false bottom.

A new water purifier is manufactured of Ransome's artificial stone. Two concentric vessels are constructed of this porous material, and, the space between them being filled with animal charcoal or other similar matter, the whole apparatus is set in a tub or tank of water which then percolates into the interior vessel from which it may be drawn in any one of several simple ways.

A new process for the manufacture of chrome salts, by the treatment of chromate of lime, (which is obtained directly from the ore,) with sulphurous acid, is announced by M. J. H. Chaudet, of Rouen. The SO_2 produced by combustion of sulphur is forced through the solution of chromate, when the lime is precipitated as sulphate, and the chromic acid reduced to a basic condition.

An excellent bone manure may be prepared, according to the Russian chemist, Illienkof, by mingling in a trench or reservoir 40 parts of ground bones, 40 parts of wood ashes, and 6 parts of quicklime, with water enough to moisten the whole, and allowing the mixture to remain some days.

Magnesium, as we learn from a paper by M. Roussin, precipitates a large number of metals from their solutions. Thus the following are thrown down as metallic powders by this body: Au, Ag, Pt, Bi, St, Hg, Cu, Pb, Cd, Tl, Fe, Tyn, Co, Ni; the elements Cr and Mn are, however, precipitated as oxides.

A remarkable fall in temperature by solution of other metals in mercury is announced by Dr. Phipson. He says that 207 parts of lead, 118 parts of tin, and 284 parts of bismuth being mixed with 1617 parts of mercury, the temperature will fall from 62°.6 to 14° F.

Gutta-percha cement is made by dissolving that body in chloroform, so as to produce a honey-like fluid. This is spread upon the articles to be secured, and allowed to dry. The pieces are then warmed until the coating softens, and are pressed together. Patches of leather may be thus put upon boots in a manner which defies equally detection and dampness.

Lemons may be preserved by coating them with a varnish of shellac dissolved in alcohol. When used the lemons are rolled and washed in water.

Sugar, it has been stated, may be made from benzole by a process lately discovered by Casius.

A curious experiment in elementary mechanics, illustrating various important laws, devised by Samuel Alsop, was lately brought to my notice by Professor A. R. Leeds, and I cannot better close my report than with this new and curious illustration.

A cord, as you perceive, is tightly stretched across the entrance of this alcove, being about twenty feet in length, and from this are hung, at equal distances in each case from the adjacent end of the cords, two equal pendulums, *i. e.*, equal strings with equal weights attached.

We now set one of these vibrating transversly to the sustaining cord. In a few moments we see that the other pendulum is beginning to swing, and that, as the motion of this second one increases, that of the first is lost, until the first comes absolutely to rest and all the motion has been transferred to the second. As soon as this condition has been reached the action is reversed, the second pendulum now giving up its motion to the first, until the second comes to rest and the first swings through a large arc. This alternation and transfer will, in fact, continue until the resistance of the air has brought the whole system to rest.

This action, though curious, and at first sight mysterious, is easy of explanation. The pendulum first started tends to set the other in motion by slight deflections of the supporting cord in a horizontal direction, but the vibration thus established in the second pendulum is of necessity (and as you easily perceive by observation) a little behind that of the first, and this relation once established is maintained throughout on account of the equality and consequent synchronism of the pendulums, so that however short the arc traversed by the first, and however long that of the second, the former is always a little ahead of the latter, and is thus dragging it on, or, in other words, giving up its own motion to it until the very last.

When, however, the first pendulum has at length come to rest, exactly the same process of transfer goes on from the moving to the stationary pendulum, as we have just described.

This experiment may be indefinitely varied by increasing the number of pendulums, and changing their directions of vibration, or weights, and is most instructive in all its forms.

Upon the conclusion of the Secretary's Report the meeting was, on motion, adjourned.

HENRY MORTON, Secretary.

BIBLIOGRAPHICAL NOTICE.

Chemical Tables. By STEPHEN P. SHARPLES, S.B. Cambridge: Sever & Francis, 1866. 12 mo., pages 192.

This very useful little volume was undertaken at the suggestion of Prof. Wolcott Gibbs of Harvard College, and executed under his immediate supervision. The high reputation of Prof. Gibbs as a physicist and analytical chemist is of itself a sufficient voucher for the judicious selection and accuracy of the tables. The student of physical science will find here collected tables of the equivalents, specific gravities, dilatations, specific heats, solubilities, in short, all the leading characteristic properties of the bodies generally met with, whether simple or compound. The factors and formulas for calculating analyses, and physical problems and experiments, are here ready at hand; and the work concludes with tables of French weights and measures, and their comparison with English, and a table of logarithms. The formulas relating to light are particularly interesting in reference to the rapidly improving methods of qualitative analysis by optical observations. Great judgment is required in selecting among the number of experiments which have been made and formulas which have been given, for many of the objects embraced in this volume; and where it was possible the authors have given the results of two or three of the most reliable observations. Where this was not possible without extending the work to unmanageable size, different physicists may, of course, differ in their opinion of the relative value of different observers, but we think that all will agree that Prof. Gibb's selection has been made with great care, and without prejudice or favoritism. We know of no book in the English language where the valuable information here contained is collected together, and we look upon it as indispensable to every one engaged in physical or chemical research, or in the application of science to the arts. We hope soon to hear that a second edition has been called for, and, in view of the recent acts of Congress, in reference to weights and measures, suggest to the authors some tables of the transformation of French into English, as well as English into French units. It is hardly necessary to say that, coming from the press of Sever & Francis, the mechanical execution of the book is everything that could be desired.

A Comparison of some of the Meteorological Phenomena of AUGUST, 1866, *with those of* AUGUST, 1865, *and of the same month for* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	August, 1866.	August, 1865.	August, for 16 years.
Thermometer—Highest—degree, .	88·00°	91·00°	97·00°
" date, .	1st & 2d.	3d & 4th.	2, '56; 4, '59.
Warmest day—mean,	81·50	84·50	88·50
" " date,	2d.	4th.	10th, '63.
Lowest—degree, .	57·00	58·00	47·00
" date, .	24th.	23d.	26th, '56.
Coldest day—mean,	62·00	64·17	59·00
" " date, .	23d.	23d.	26th, '56.
Mean daily oscillation,	14·03	12·13	15·42
" " range, .	3·77	3·29	3·69
Means at 7 A. M., .	67·82	72·10	70·84
" 2 P. M., .	78·36	81 02	81·18
" 9 P. M., .	71·32	74·56	73·89
" for the month,	72·50	75·89	75·30
Barometer—Highest—inches, .	29·957 ins.	30·141 ins.	30·255 ins.
" date, . .	17th.	1st.	20th, '55.
Greatest mean daily press.	29·935	30·127	30·229
" " date, .	12th.	1st.	20 & 31, '55.
Lowest—inches, . .	29·376	29·540	29·356
" date, . .	9th.	22d.	20th, '56.
Least mean daily press.,	29·459	29·557	29·388
" " date, .	9th.	22d.	20th, '56.
Mean daily range, .	0·096	0·089	0·094
Means at 7 A. M., .	29·750	29·847	29·858
" 2 P. M., .	29·711	29·814	29·839
" 9 P. M., .	29·751	29·847	29·851
" for the month, .	29·737	29·836	29·846
Force of Vapor—Greatest—inches,	0·818 in.	0·890 in.	1·024 in.
" date, .	9th.	5th.	1st, '54.
Least—inches, .	·351	·294	·268
" date, .	17th.	24th.	often.
Means at 7 A. M., .	·522	·575	·583
" 2 P. M., .	·547	·596	·591
" 9 P. M., .	·568	·596	·611
" for the month,	·546	·589	·595
Relative Humidity—Greatest—per ct.,	95·0 per ct.	85·0 per ct.	100·0 per ct.
" date,	13th & 14th.	22d.	26th, '54.
Least—per ct.,	42·0	41·0	27·0
" date, .	18th.	24th.	1st, '60.
Means at 7 A. M.,	75·4	71·4	76·1
" 2 P. M.,	56·7	55·3	56·0
" 9 P. M.,	73·7	69·1	72·7
" for the month	68·6	65·3	68·3
Clouds—Number of clear days,* .	10	8	9·5
" cloudy days, .	21	23	21·5
Means of sky cov'd at 7 A. M.,	52·9 per ct.	61·3 per ct.	55·9 per ct.
" " " 2 P. M.,	59·7	66·1	61·2
" " " 9 P. M.,	36·1	25·5	41·5
" " for the month	49·6	51·0	52·9
Rain—Amount, ...	2·567 ins.	2·993 ins.	3·750 ins.
No. of days on which rain fell, .	12	6	9·7
Prevailing Winds—Times in 1000,	s86° 56′w ·336	s74°13′w ·270	s77°26′ w ·129

* Sky one-third or less covered at the hours of observation.

A Comparison of some of the Meteorological Phenomena of the SUMMER *of* 1866 *with that of* 1865, *and of the same season for* FIFTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	Summer, 1866.	Summer, 1865.	Summer, for 15 years.
Thermometer—Highest—degree, .	101·00°	97·00°	101·00°
" date, .	July 17th.	July 7th.	July 17, '66
Warmest day—mean,	92·33	87·33	92·33
" " date,	July 17th.	July 28th.	July 17, '66
Lowest—degree, .	56·00	58·00	42·00
" date, .	June 1st.	Aug. 23d.	June 5th, '59
Coldest day—mean,	62·00	64·17	55·00
" date, .	Aug. 23d.	Aug. 23d.	June 6th, '61
Mean daily oscillation,	14·56	12·50	15·79
" " range, .	4·23	4 08	4·14
Means at 7 A. M., .	71·12	73·55	71·21
" 2 P. M., .	81·71	82·58	81·32
" 9 P. M., .	74·07	75 32	73·87
" for the Summer,	75·63	77·15	75·47
Barometer—Highest—inches, .	30·072 ins.	30·141 ins.	30·281 ins.
" date, . .	July 2d.	Jy.31, Aug.1.	June 14th, '52
Greatest mean daily press.	30·015	30·127	30·251
" date, . .	July 2d.	Aug. 1st.	June 13th, '52
Lowest—inches, .	29·376	29·537	29·182
" date, . .	Aug. 9th.	July 17th.	June 11th, '57
Least mean daily press.,	29·459	29·557	29·262
" date, . .	Aug. 9th.	Aug. 22d.	June 11th, '57
Mean daily range, .	0·095	0·086	0·096
Means at 7 A. M., . .	29·764	29·822	29·833
" 2 P. M., . .	29·725	29·796	29·802
" 9 P. M., . .	29·753	29·820	29·821
" for the Summer,	29·747	29·813	29·819
Force of Vapor—Greatest—inches,	0·980 in.	0·917 in.	1·059 in.
" date, .	July 17th.	July 25th.	June 30th, '55
Least—inches, .	·265	·294	·142
" date, .	June 1st.	Aug. 24th.	June 14th, '61
Means at 7 A. M., .	·574	·605	·570
" 2 P. M., .	·580	·622	·278
" 9 P. M., .	·620	·626	·601
" for the Summer,	·591	·618	·583
Relative Humidity—Greatest—per ct.,	95·0 per ct.	90 0 per ct.	100 per ct.
" date,	Aug. 13 & 14.	J'e 9, J'y 25.	26A '54, 6J'56
Least—per ct.,	36·0	37·0	22·0
" date, .	July 31st.	July 9th.	June 16th, '63
Means at 7 A. M.,	73·6	71·9	73·2
" 2 P. M.,	53·6	55·5	54·1
" 9 P. M.,	72·5	70·5	71·1
" for the Summer,	66·6	65·9	66·1
Clouds—Number of clear days,* .	33	26	26·0
" cloudy days, .	59	66	66·0
Means of sky cov'd at 7 A. M.,	52·4 per ct.	60·8 per ct.	58·3 per ct.
" " " 2 P. M.,	57·4	64·6	60·7
" " " 9 P. M.,	41·0	36·4	42·6
" " for the Summer,	50·3	53·9	53·9
Rain—Amount, ...	8·470 ins.	9·943 ins.	11·666 ins.
No. of days on which rain fell, . .	36	26	32·5
Prevailing Winds—Times in 1000,	s71°48′w·301	s73°42′w·213	s71°15′w·174

* Sky one-third or less covered at the hours of observation.

JOURNAL

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OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

NOVEMBER, 1866.

CIVIL AND MECHANICAL ENGINEERING.

For the Journal of the Franklin Institute.

The Preservation of Wood in Damp and Wet Situations. By H. W. Lewis, University of Michigan.

(Concluded from page 223.)

In 1846, eighty thousand sleepers of the most perishable woods, impregnated, by Boucherie's process, with sulphate of copper, were laid down on French railways. After nine years exposure, they were found as perfect as when laid.* This experiment was so satisfactory that most of the railways of that empire at once adopted the system. We would suggest washing out the sap with water, which would not coagulate its albumen. The solution would appropriately follow.

Both of the last named processes are comparatively cheap. The manufacturing companies of Lowell, Mass., have an establishment for "Burnettizing" timber,† in which they prepare sticks 50 feet in length. Under a pressure of 125 pounds per square inch, they inject from two to eight ounces of the salt into each cubic foot of wood. The cost, in 1861, was from $5 to $6 per 1000 feet, board measure.‡ Boucherie's method must be still cheaper. It costs less than creosoting by one shilling per sleeper.§

An American engineer, Mr. Hewson, for injecting railroad sleepers,

* *Jour. of the Frank. Inst.*, vol. xxxii., pp. 2, 3. † *New American Cyclopædia.*

‡ The Philadelphia, Wilmington and Baltimore Railroad Company have used the process since 1860 with complete success. The Union Pacific Railroad Company have recently erected a large building for this purpose. Their cylinder is 75 feet long, 61 inches in diameter, and capable of holding 250 ties. They "Burnettize" two batches per day. *Report on Pacific Railroad* by Col. Simpson, 1865.

§ *Jour. Frank. Inst.*, vol. xxxii., pp. 2, 3.

proposes a vat deep enough for the timbers to stand upright in. The pressure of the surrounding solution upon the lower ends of the sticks will, he thinks, force the air out at their upper extremities, kept just above the surface of the solution, after which the latter will rise and impregnate the wood. In 1859, he estimated chloride of zinc at 9 cents per pound, sulphate of copper at 14 cents per pound, and pyrolignite of of iron at 23 cents per gallon. He found the cost of impregnating a railway tie with sufficient of those salts to prevent decay, to be—for the chloride of zinc 2·8 cents, for blue vitriol 3·24 cents, for pyrolignite of iron 7·5 cents.*

Among the numerous other preservative compounds, may be mentioned Le Gras' mixture† of a double salt of manganese and lime (or zinc) with creosote, Payne's solutions‡ of sulphate of iron and muriate of lime, forming by double decomposition an insoluble sulphate of lime among the wood fibres, Margary's solution of acetate of copper, and Ransome's liquid silicate of potassa.§ Payne's process met with some favor. But neither of the last are of appreciable value.

Vessel owners had long ago observed that those ships which have early sailed with cargoes of salt are not attacked by dry rot. Indeed, several instances are well attested of vessels, whose interiors were lined with fungi, having all traces of the plant destroyed by accidental or intentional sinking in the sea. Acting on such hints, a trader of Boston salted his ships with 500 bushels of the chloride, disposed as an interior lining, adding 100 bushels at the end of two years.‖ Such an addition of dead weight, (35,000 pounds in this case,) is sufficient objection to a procedure which has other great disadvantages.

The unpleasant odor of creosote is greatly against its use upon lumber for dwellings, and Bethell's process, therefore, is not described here, although the most satisfactory known. Pyrolignite of iron is offensive and also highly inflammable. The affinity of the chlorides for water keeps the structure into which they are introduced wet; besides, they corrode the iron-work. Sulphate of copper is free from these objections, and is, at present, cheaper than the chlorides.¶ Therefore, *for protecting wooden structures against dry rot* in damp situations, like mines, vaults, and the basements of buildings, *sulphate of copper seems preferable, and Hewson's or Boucherie's method of injecting it cheaper and more expedient, according as the timber is short or long.*

II. *Wood alternately wet and dry.*—The surface of all timber ex-

* *Jour. Frank. Inst.*, vol. xxvii., page 8. † *Civ. Eng. Jour.*, vol. xviii., p. 20.

‡ Ibid., vol. vi., p. 207.

§ Fifty pounds of carbonate of potassa are dissolved in water, and a little lime is added to neutralize any free acid. 100 pounds of flints are added and the whole exposed 10 or 12 hours to a temperature of 300° F. This solution is evaporated to 1·500 at 60°.—*Civil Engineer's Journal*, vol. ix.

‖ *American Journal of Science*, vol. ii., p. 17.

¶ Price of sulphate of copper per pound $11\frac{3}{4}$ and 12 cents; sulphate of zinc 8 and 12 cents; chloride of zinc $1·60 and $1·75; chloride of mercury, $1·08 and $1·10. —From *Druggist's Circular*, June ,1866.

The price paid for chloride of zinc by the Michigan Central Railroad Company, two years ago, was 6 cents per pound.—*Auditor's Office, M. C. RR. Co.*

posed to alternations of wetness and dryness, gradually wastes away, becoming dark-colored or black. This is really a slow combustion, but is commonly called wet rot, or simply rot. Other conditions being the same, the most dense and resinous woods longest resist decomposition. Hence the superior durability of the heart-wood, in which the pores have been partly filled with lignine, over the open sap-wood, and of dense oak and lignum-vitæ over light poplar and willow. Hence, too, the longer preservation of the pitch-pine and resinous "jarrah" of the East, as compared with non-resinous beech and ash.

Density and resinousness exclude water. Therefore our preservatives should increase those qualities in the timber. Fixed oils fill up the pores and increase the density. Staves from oil barrels and timbers from whaling ships are very durable. The essential oils resinify, and furnish an impermeable coating. But pitch or dead oil possesses advantages over all known substances for the protection of wood against changes of humidity. According to Professor Letheby,* dead oil, 1st, coagulates albuminous substances; 2d, absorbs and appropriates the oxygen in the pores, and so protects from eremacausis; 3d, resinifies in the pores of the wood, and thus shuts out both air and moisture; and, 4th, acts as a poison to lower forms of animal and vegetable life, and so protects the wood from all parasites. All these properties specially fit it for impregnating timber exposed to alternations of wet and dry states, as, indeed, some of them do, for situations damp and situations constantly wet. Dead oil is distilled from coal-tar, of which it constitutes about ·30, and boils between 390° and 470° Fahr. Its antiseptic quality resides in the creosote it contains. One of the components of the latter, carbolic acid (phenic acid, phenol) $C_{12}\ H_6\ O_2$,† the most powerful antiseptic known, is able at once to arrest the decay of every kind of organic matter.‡ Prof. Letheby estimates this acid at $\frac{1}{2}$ to 6 per cent. of the oil. Chrysilic acid $C_{14}\ H_8\ O_2$, the homologue of carbolic acid, and the other component of creosote, is not known to possess preservative properties.

Bethell's process§ subjects the timber and dead oil, enclosed in huge

* *Civil Engineer's Journal*, vol. xxiii., page 216.

† "Creosote from coal undoubtedly contains two homologous bodies, $C_{12}\ H_6\ O_2$ and $C_{14}\ H_8\ O_2$, the first being carbolic and the second cresylic acid."—Ure's *Dict. of Arts, Manu., and Mines*, vol. ii, p. 623.

‡ "I have ascertained that adding one part of carbolic acid to five thousand parts of a strong solution of glue will keep it perfectly sweet for at least two years. . . . . Hides and skins, immersed in a solution of one part of carbolic acid to fifty parts of water, for twenty-four hours, dry in air and remain quite sweet."—Prof. Crace Calvert, *Ann. Sc. Discov.*, 1865, p. 55.

"Carbolic acid is sufficiently soluble in water for the solution to possess the power of arresting or preventing spontaneous fermentation. Saturated solutions act on animals and plants as a virulent poison, though containing only five per cent. of the acid."—*Civ. Eng. Jour.*, vol. xxii., p. 216.

"Parasitic and other worms are instantly killed by a solution containing only one-half per cent. of acid, or by exposure to the air containing a small portion of the acid . . . . By examining the action on a leaf, we find the albumen is coagulated. All animals with a naked skin, and those that live in water, die sooner than those that live in air and have a solid envelope."—Dr. I. Lemaire *Ann. Sc. Discov.*, 1865, p. 238.

§ Ronald and Richardson's *Technology*, p. 739.

iron tanks, to a pressure varying between 100 and 200 pounds per square inch, about twelve hours. From eight to twelve pounds of oil are thus injected into each cubic foot of wood. Lumber thus prepared is not affected by exposure to air and water, and requires no painting.* A large number of English railway companies have already adopted the system.† Eight pounds of oil per cubic foot is sufficient for railway sleepers.‡

The cost of "creosoting," as this process is sometimes called, was given in 1855, by Ronald and Richardson, at somewhat less than four pence per cubic foot,§ in England. At one shilling per gallon,‖ the price at which dead oil was obtainable in England in 1863, four pence per cubic foot would, we presume, be sufficient.

A process recently patented, and described in the *Scientific American*, February 17, 1866, proposes to introduce highly heated oleaginous vapors among the timber, confined in an iron tank. The patentee¶ hopes, that as fast as the moisture is expelled from the wood, the vapor will take its place. Whether this substitution would not soon arrest itself, should it even commence, is in our mind a debatable question.

While an external application of coal-tar promotes the preservation of dry timber, nothing can more rapidly hasten decay than such a coating upon the surface of green wood. But this mistake is often made, and dry rot, instead of wet rot, does the work of destruction.** The reason must appear from what has been said on dry rot. Carbonizing the surface also increases the durability of dry, but promotes the decay of wet, timber. Farmers very often resort to one of the latter methods for the preservation of their fence-posts. Unless they discriminate between green and seasoned timber, these operations will prove injurious instead of beneficial.

In this connection, we remark, that inverting a post from the position in which it grew, is by some supposed to retard decay. According to the President of the "Northern Architect's Association," England, "the *valves*" close against moisture ascending through the ducts from the earth into the post.†† But, according to Gray, thin places only separate contiguous ducts. Fluids can pass through them in *one* direction as well as in the *other*. When age obliterates these thin mediums, nothing opposes the flow upward or downward. Furthermore, the passage of fluids through wood is not confined to ducts: it takes

* Ure's *Dict. of Manu. and Mines.*

† The Great Western, North-Eastern, Bristol and Exeter, Stockton and Darlington, Manchester and Birmingham, and London and Birmingham.—Ure's *Dict. of Manu. and Mines.*

‡ *Jour. Frank. Inst.*, vol. xliv., p. 275.

§ *Chemical Technology*, p. 737.

‖ Dr. J. G. Ashby in the *London Mechanic's Magazine*, July, 1862. He says, "Crude carbolic acid can be obtained for one shilling," but undoubtedly means dead oil.

¶ Louis S. Robbins, New York City.

** According to Col. Berrien, the Michigan Central Railroad bridge, at Niles, was painted, *before seasoning*, with "Ohio fire-proof paint," forming a glazed surface. About five years after, it was so badly dry rotted as to require rebuilding.

†† The *Builder* for 1866, p. 79.

place on all sides of them as well. In face of these facts, very careful experiments will be requisite to convince us that a post is more durable in the inverted than in the normal position.

III. *Timber constantly wet in salt water.*—We have not to guard against decay when timber is in this situation. Teredo navalis, a mollusk of the family Tubicolària, Lam., soon reduces to ruins any unprotected submarine construction of common woods. I quote from a paper read before the "Institute of Civil Engineers," England, illustrating the ravages of this animal:

"The sheeting at Southend pier extended from the mud to eight feet above low-water mark. The worm destroyed the timber from two feet below the surface of the mud to eight feet above low-water mark, spring-tide; and out of 38 fir-timber piles and various oak-timber piles, not one remained perfect after being up only three years."* Specimens of wood, taken from a vessel that had made a voyage to Africa, are in the museum, and show how this rapid destruction is effected.

None of our native timbers are exempt from these inroads. Robert Stephenson, at Bell Rock, between 1814 and 1843,† found that greenheart oak, beef-wood, and bullet-tree were not perforated, and teak but slightly so. Later experiments show that the "jarrah" of the East, also, is not attacked.‡ The cost of those woods obliges us to resort to artificial protection.

The teredo never *perforates* below the surface of the sea-bottom,§ and probably does little injury above low-water mark. Its minute orifice, bored across the grain of the timber, enlarges inwards to the size of the finger, and soon becomes parallel to the fibre. The smooth circular perforation is lined throughout with a thin shell which is sometimes the only material separating the adjacent cells. The borings undoubtedly constitute the animal's food, portions of woody fibre having been found in its body.‖ While upon the surface only the projecting siphuncles indicate the presence of the teredo, the wood within may be absolutely honey-combed with tubes from one to four inches in length.

It was naturally supposed that poisoning the timber would poison or drive away the teredo, but Kyan's, and all other processes employing solutions of the salts of metals or alkaline earths, signally failed. This, however, is not surprising. The constant motion of sea-water soon dilutes and washes away the small quantity of soluble poison with which the wood has been injected. If any albuminate of a metallic base still remains in the wood, the poisonous properties of the injection have been destroyed by the combination. Moreover, the lower vertebrates are unaffected by poisons which kill the mammals. Indeed, it is now known that certain of the lower forms of animal life live and even fatten on such deadly agents as arsenic.¶

* *Civ. Eng. Jour.*, vol. xii., page 382.

† Ibid., vol. xx., p. 16.

‡ The *Builder* for 1862, p. 511.

§ *Civ. Eng. Jour.*, vol. xx., p.

‖ Ibid., vol. xii., p. 382. Also *Dict. Univer. d'His. Natur.*, tome xii.

¶ *British and Foreign Medical Review.*

Coatings of paint or pitch are too rapidly worn away by marine action to be of much use, but timber, thoroughly creosoted with ten pounds of dead oil per cubic foot, is perfectly protected against teredo navalis. All recent authorites agree upon this point. In one instance, well authenticated, the mollusk reached the impregnated heart-wood by a hole carelessly made through the injected exterior. The animal pierced the heart-wood in several directions, but turned aside from the creosoted zone.* The process and cost of "creosoting" have already been discussed.

A second destroyer of submarine wooden constructions is limnoria terebrans, (or L. perforata, Leach,) a mollusk of the family Assellotes, Leach, resembling the sow-bug. It pierces the hardest woods with cylindrical, perfectly smooth, winding holes, $\frac{1}{20}$th to $\frac{1}{15}$th of an inch in diameter, and about two inches deep†. From ligneous matter having been found in its viscera, some have concluded that the limnoria feeds on the wood, but since other mollusks of the same genius, Pholas, bore and destroy stone-work, the perforation may serve only for the animal's dwelling. The limnoria seems to prefer tender woods, but the hardest do not escape. Green-heart oak is the only known wood which is not speedily destroyed.‡ At the harbor of Lowestoft, England, square fourteen inch piles were, in three years, eaten down to four inches square.§

While all agree that no preparation, if we except dead oil, has repelled the limnoria, an eminent English engineer has cited three cases in which that agent afforded no protection.‖

We do not find that timber impregnated with water-glass has been tested against this subtle foe. The experiment is certainly worthy of a trial.

A mechanical protection is found in thickly studding the surface of the timber with broad-headed iron nails. This method has proved successful.¶ Oxydation rapidly fills the interstices between the heads, and the outside of the timber becomes coated with an impenetrable crust, so that the presence of the nails is hardly necessary.

In conclusion, we cannot but express surprise that so little is known in this country concerning preservative processes. Their employment seems to excite very little interest, and the very few works where they are being tested attract hardly any attention. Those railroads which have suspended their use assign no reasons, and those upon which the timber is injected publish no reports concerning the advantages of their particular methods. Even the National Works, upon which Kyan's process was formerly employed, have laid it aside, and now subject lumber to dampness and alternations of wetness and dryness, without any preparation beyond seasoning. When sleepers cost fifty cents and creosoting thirty cents each, it is cheaper to hire money at seven per cent., compound interest, than to lay new sleepers at the end of seven years. Allowing any ordinary price for the removal of the old and laying down the new ties, the advantage of using Bethell's process

* *Civ. Eng. Jour.*, vol. xii., page 191.

† *Dict. Univer. d'His. Natur.*

‡ *Civ. Eng. Jour.*, vol. xxv., p. 206.

§ Ibid., vol. xvi., p. 76.

‖ Ibid., vol. xxv. p. 206.

¶ Ibid., vol. xii., p. 382.

seems evident. If some cheaper method will produce the same effects, the folly of neglecting *all* means seeking to increase the durability of the material is still more palpable.

Complete and reliable reports upon the preservation of the various species of woods experimented upon in this country are greatly needed, and we hope they may shortly appear.

For the Journal of the Franklin Institute.

Limes, Cements, Mortars, and Concretes. By Chas. H. Haswell, C.E., New York.

(Continued from volume l., page 175.)

Tables *showing the Resistance to Transverse Strains of Concretes, Cements, Mortars, Puzzuolana, and Trass.*

Reduced to a bar 1 inch square and 1 foot in length. Supported at both ends.

$\frac{2}{3}\,\frac{l\,w}{4\,b\,d^2} = v$ per square inch of section; represents value for general use, being $\frac{2}{3}$ of ultimate breaking strain.

EXPERIMENTS OF VOISIN, 1857.

Mortar.			Concrete.				
One volume of sand.			One volume of pebbles.		Calculated value of v.		
Cement.	Water.	Volume produced.	Mortar.	Volume produced.	10 days.	20 days.	60 days.
1	·62	1·69	1	1·56	2·3	2·3	2·9
			½	1·03	1·7	2·8	3·2
			⅓	1·	1 8	2·3	3·1
			¼	1·	1·	1·4	1·
½	·43	1·24	1	1·45	1·6	1·9	2·7
			⅔	1·11	1·6	2·	2·1
			½	1·	1·	1·4	1·9
⅓	·38	1·12	1	1·4	·86	·95	·91
			⅔	1·11	·68	·98	1·3
			½	1·03	·58	·76	1·2
¼	·35	1·05	1	1·4	·48	·74	1·
			⅔	1·14	·32	·61	·92
			½	1·01	·35	·51	·85
⅕	·34	1·	1	1·45	·3	·65	·83
			⅔	1·13	·24	·48	·09
			½	1·03	·44	·43	·65
⅙	·32	·96	1	1·45	·41	·41	·81
			⅔	1·13	·28	·42	·72
			½	1·03	·36	·38	·79

EXPERIMENTS OF GEN. TOTTEN, 1837.

CONCRETE.*	MORTAR. Cement ... 1· Sand...... ·0 Lime ...... ·0	Cement ... 1· Sand...... ·5 Lime ...... ·0	Cement ... 1· Sand...... ·5 Lime ...... ·25	Cement ... 1· Sand...... 1· Lime ...... ·0
	V.	V.	V.	V.
Granite ... 1, Mortar ... 1	2·9	2·4	1·6	2·3
Granite ... 1, Mortar ... 2	2·4	2·9	2·9	2·4
Brick† ... 1, Mortar ... 1	1·9	1·2	....	2·4
Brick ... 1, Mortar ... 2	1·6	2 9	1·6	2·6
Gravel ... 1, Mortar ... 1	·6	·6	·7	·7
Gravel ... 1, Mortar ... 2	1·4	2·4	1·5	·7
Stone ..., Gravel ...	1·9	1·	1·1	·6
Brick ..., Gravel ...	·9	1·4	1·6	1·6

* The granite, bricks, &c., were broken into fragments or spalls of the required size.

† Brick gravel gave 50 per cent. greater resistance than the fragments.

EXPERIMENTS OF GEN. GILMORE.

MATERIALS.	CEMENTS AND MIXTURES.	Calculated value of V.
Rosendale, 95 days	Pure	7·
	Cement 1, Lime ¼	6·7
	Cement 1, Lime ½	5·6
	Cement 1, Lime ¼	5·1
	Cement 1, Lime 1	3·9
James River, 59 days	Cement 4· values, Water 2·6 "	1·9
	Cement 4· ", Water 1·4 "	3·4*
Rosendale, (Hoffman,) 320 days	Stiff paste, " "	4·4*
	Thin ", " "	4·8*
Delafield and Baxter	Stiff "	6·*

* All except the first were submitted to a pressure of 32 lbs. per square inch.

MATERIALS.	CEMENTS AND MIXTURES.	Calculated value of v.
Portland, (Eng.,) 320 days	Pure cement	10·6
	Cement 1 Sand 1	8·7
	Cement 1 Sand 2	6·6
Roman, (Eng.,) 100 days	Cement 1 Sand 1	4·
Portland Pure, (Eng.,) 270 days	Cement 1 Sand 1	12·5 13·
	Cement 1 Sand 2	8·5
High Falls, (N. Y.,) 270 days	Pure	11·3
James River	Cement 1 Sand 1	5·9
	Fresh	4 3

NOTE.—When the paste is not subjected to compression during setting, a thin paste produces about as strong a mortar as a stiff one.

CEMENT.	Calculated value of v.		
	Pure.	Cement 1. Sand... 1.	Cement 1. Sand... 2.
Portland, English, (artificial)	10·5	8·6	6·5
Cumberland, Md	6·5	6·3	3·8
Newark and Rosendale	5·8	3·8	3·4
Round Top, Md	....	4·1	....
Utica, Ill	5·1	1·2	3·8
Shepherdstown, Va	5·1	4·2	3·1
Akron, New York	5·2	4·4	4·1
Brighton and Rosendale	4·9	3·8	3·4
Sandusky, Ohio	3·8	3·2	....
James River, Va	....	4·2	4.4
Rosendale, Lamenceuth	....	6·2	....
Hoffman	5·8	4·1	....
Lawrence	5·3	....	....
Remington, Conn	6·5	4·8	3·4

EXPERIMENTS OF GEN. TREUSSART.

PUZZUOLANA AND TRASS—MORTAR.			Calculated value of v.
Strasburgh	Lime 1 Sand 1 Trass 1	5 days	2·8
	Lime 1 Trass 2	4 "	2·3
	Lime 1 Sand 1 Puzzuolana 1	4 "	3·4

PUZZUOLANA AND TRASS—MORTAR.			Calculated value of v.
White Marble........	Lime.............. 1, Sand.. .... 1, Trass. 1	5 days......	2·1
	Lime...... .... 1, Sand.................. 1, Puzzuolana........ 1	4 "	2 7
Strasburgh......................	Lime paste....... 1, Puzzuolana 2½	5 "	3·8
	Lime paste......... 1, Trass.................. 2	8 "	3·1

Portland cement, 4 months..	21·3
Roman " 4 "	14·8
Fire brick beam,* loaded partly along the centre....................	2·1
Cement paste, 95 days..	13·8
" " 1, lime paste ¼..	13·6
" " 1, " " ½..	11·3
" " 1, " " ¾..	7·8
" " 1, " " 1..	7·9
" " ¾, " " 1..	5·
" " ½, " " 1..	4·2

* Broke through the bricks.

Tensile Resistance of various Cements, Mortars, and Masonry per square inch.

EXPERIMENTS OF VICAT AND CHATONEY AT CHERBOURG, GEN. GILMORE, CRYSTAL PALACE, LONDON, &C.

MATERIALS AND MIXTURES.	Ultimate resistance.
Boulogne, 100 parts, water 50..	112
90 days, 100 parts, water 50..	52
Boulogne, 1 year, Portland, (natural)..	675
English, 1 year, Portland, (artificial)..	462
Roman, 1 year, from Septaria..	191
" 42 days, cement 1, sand 1..	284
" " " 1. " 2..	199
" " " 1, " 3..	166
Portland, " " 1, " 1..	142
" " " 1, " 2..	113
" " " 1, " 3..	192
" 15 days " 6, water 4..	134
" 45 " " 6, water 4..	207
" 135 " " 6, water 4..	233
" English, 320 days, pure..	1152
" " " cement 1, sand 1..	948
" " " " 1, " 2..	713
Roman, " 100 days, " 1, " 1..	439
Portland, 45 days, pure and mixed, stiff..	206
" English, pure, 1 month..	393
" " " 6 months..	424
Stone masonry, Roman cement, 5 months..	77

BRICK AND GRANITE MASONRY, 320 DAYS.

Cement, Delafield and Baxter	Pure	68·56
	Cement 4, Sand 1	68·5
	Cement 5, Siftings 1	79 87
	Cement 1, Siftings 2	74·5
" Lawrence Co	Pure	87·37
	Pure	53·68
" James River	Cement 4, Sand 1	62·
" Newark Lime and Cement Co	Pure	93·25
	Cement 1, Sand 2	89·62
" Brighton and Rosendale	Pure	80·25
" Newark and Rosendale	Pure	75·81
" Pure upon bricks		31·
" 1, sand 1 pure upon bricks		16·
" 1, " 3 " "		7·
" pure upon granite		27·
" 1, water ½		20·
" 1, " 42		27·
" pure upon bricks with mortar in the joint, mean		6·
" " " without mortar, mean		45·
Lime paste 1, Sand 3	upon bricks	6·
Lime paste 1, Sand 2	" "	4·13
Lime paste 1, Sand 3, Cement paste 5	" "	11·41

TABLE SHOWING THE RESISTANCE TO CRUSHING STRAIN OF CEMENTS, STONE, &C., (CRYSTAL PALACE, LONDON.)

MATERIAL.	Ultimate pressure per square inch.
Portland cement, area 1, heigth 1	1680
" " 1, Sand 1	1244
Cement 1, Sand 4	1244
Roman cement, pure	342

Deductions.—1st. Particles of unground cement exceeding $\frac{1}{80}$ inch in diameter may be allowed in cement paste without sand to the extent of 50 per cent. of the whole, without detriment to its adhesive or cohesive properties, while a corresponding proportion of sand injures the strength of the mortars in these respects about 40 per cent.

2d. That when these unground particles exist in the cement paste to the extent of 66 per cent. of the whole, the adhesive strength is diminished about 28 per cent. For a corresponding proportion of sand the diminution is 68 per cent.

3d. The addition of siftings exercises a less injurious effect upon the cohesive than upon the adhesive property of cement. The converse is true when sand, instead of siftings, is used.

4th. In all the mixtures with siftings, even when the latter amounted to 66 per cent of the whole, the cohesive strength of the mortars exceeded its adhesion to the bricks. The same results appear to exist when the siftings are replaced by sand, until the volume of the latter exceeds 20 per cent of the whole, after which the adhesion exceeds the cohesion.

5th. At the age of 320 days (and perhaps considerably within that period) the cohesive strength of pure cement mortar exceeds that of Croton front bricks. The converse is true when the mortar contains 50 per cent. or more of sand.

6th. When cement is to be used without sand, as may be the case when *grouting* is resorted to, or when old walls are to be repaired by injections of thin paste, there is no advantage in having it ground to an impalpable powder.

7th. For economy it is customary to add lime to cement mortars, and this may be done to a considerable extent when in positions where hydraulic activity and strength are not required in an eminent degree.

Slaking.—The volume of water required to slake lime will vary with limes from 2·5 to 3 times the volume of the lime, (quicklime,) and it is important that all the water required to reduce the lime to a proper consistency should be given to it before the temperature of the water first given becomes sensibly elevated.

Immediately upon the lime being provided with the requisite volume of water, it should be covered, in order to confine the heat, and it should not be stirred whilst slaking. When the paste is required for *grouting* or *whitewashing*, the water required should be given at once, and in larger volume than when the paste is required for mortar, and when slaked the mass should be transferred to tight casks to prevent the loss of water. When the character of the limes, as with those of hydraulic energy, will not readily reduce, their reduction, which is an indispensable condition, must be aided by mechanical means, as a mortar mill.

TABLE SHOWING THE COMPARATIVE VOLUMES OF LIME AND SLAKED LIME.
WEIGHT OF VOLUME OF LIME 5 POUNDS.

LIME.	Volume—			Ratio of increase.	
	Before slaking.	After slaking.	Of water.	Weight.	Volume.
	Cub. in.	Cub. in.	Cub. in.		
Rockland, lump.......	91·2	224·2	....	2·24	2·46
Sing Sing, lump......	87·4	227·	210·	2·22	2·61
Rondout, ground......	110·2	222·3	195·7	2·12	2·
Glenn Falls, lump....	93·1	304·	279·3	2·7	3·26
" by immersion	91·2	202·8	181·5	2·1	2·54

The process here given is termed *drowning*. When the lime is retained in a barrel, or like instrument, immersed in water, and then withdrawn before reduction occurs, it is termed *immersion*, and when it is reduced by being exposed to the atmosphere, and gradually absorbing moisture therefrom, it is termed *air-slaked.*

Bricks should be well wetted before use. *Sea sand* should not be used in the composition of mortar, as it contains salt and its grains are round, being worn by attrition, and consequently having less tenacity than sharp-edged grains.

Fine Clay.—The fusibility of clay arises from the presence of impurities, such as lime, iron, and manganese. These may be removed by steeping the clay in hot muriatic acid, then washing it with water. Crucibles from common clay may be made in this manner.

Pisé is made of clay or earth rammed in layers of from 3 to 4 inches in depth. In moist climates it is necessary to protect the external surface of a wall constructed in this manner with a coat of mortar.

Asphalt Composition.—Mineral pitch 1 part, bitumen 11, powdered stone, or wood ashes, 7 parts.

2. Ashes 2 parts, clay 3 parts, and sand 1 part, mixed with a little oil, makes a very fine and durable cement, suitable for external use.

Mastic.—Pulverized burnt clay 93 parts, litharge ground very fine 7 parts, mixed with a sufficient quantity of pure linseed oil.

3. Silicious sand 14, pulverized calcareous stone 14, litharge $\frac{1}{14}$ of the weight of the sand and stone, and linseed oil $\frac{1}{7}$ of the total weight of the materials.

The powders to be well dried in an oven, and the surface upon which it is to be applied must be saturated with oil.

4. *For Roads.*—Bitumen 16,875 parts, asphaltum 225 parts, oil of resin 6·25 parts, and sand 135 parts. Thickness, from $1\frac{1}{4}$ to $1\frac{5}{8}$ inches.

Asphaltum 55 lbs. and gravel 28·7 lbs. will cover an area of 10·75 square feet.

Notes by General Gilmore, U. S. A.—All the lime necessary for any required quantity or "batch" of mortar should be slaked at least one day before it is mixed with the sand.

All the water required to slake the lime should be poured on at one time, the lime should be submerged, and the mass should then be covered with a tarpaulin or canvas, and allowed to remain undisturbed for a period of 24 hours.

The ingredients should be thoroughly mixed, and then heaped for use as required.

Recent experiments have developed that most American cements will sustain, without any great loss of strength, a dose of lime paste equal to that of the cement paste, whilst a dose equal to $\frac{1}{2}$ to $\frac{3}{4}$ the volume of current paste may be safely added to any Rosendale cement without producing any essential deterioration of the quality of the mortar. Neither is the hydraulic activity of the mortars so far impaired by this limited addition of lime paste as to render them unsuited for concrete under water, or other submarine masonry. By the

use of lime is secured the double advantages of slow setting and economy.

Pointing Mortar is composed of a paste of finely ground cement and clean sharp silicious sand, in such proportions that the volume of cement paste is slightly in excess of the volume of voids or spaces in the sand. The volume of sand varies from $2\frac{1}{2}$ to $2\frac{3}{4}$ that of the cement paste, or by weight, 1 of cement powder to 3 to $3\frac{1}{3}$ of sand. The mixture should be made under shelter, and in quantities not exceeding from 2 to 3 pints at a time.

Before pointing, the joints should be reamed, and in close masonry they must be open to $\frac{3}{16}$ of an inch, then thoroughly saturated with water and maintained in a condition that they will neither absorb water from the mortar, or impart any to it. Masonry should not be allowed to dry rapidly after pointing, but it should be well driven in by the aid of a caulking iron and hammer. This operation should be repeated until the joint is entirely full.

In the pointing of rubble masonry the same general directions are to be observed.

Notes by General Totton, U. S. A.—240 lbs. lime = 1 cask, will make from 7·8 to 8·15 cubic feet of stiff paste.

308* lbs. of finely ground cement will make from 3·7 to 3·8 cubic feet of stiff paste. 79 to 83 lbs. of cement powder will make 1 cubic foot of stiff paste.

1 cubic foot of dry cement powder, measured when loose, will measure ·78 to ·8 cubic foot when packed, (as at a manufactory.)

100 yards of lath and plaster work, with wages of mason at $1·75 per day, and Rockland lime at $1 per cask, cost, respectively—

3 coats hard finish work	$25·50
2 coats slipped work	19·95

* 300 lbs. net is the standard barrel, but it usually weighs 308 lbs.

For the Journal of the Franklin Institute.

A new Marine Signal Light. By R. H. Thurston, 1st Asst. Eng., United States Navy.

The metal magnesium, to which so much attention has been drawn lately by its remarkable illuminating power, was discovered by Sir Humphrey Davy at about the same time that he discovered the metals of the alkalies, and by a similar method. It is a white metal, quite similar in appearance to silver, but remarkable for its lightness, a cubic inch weighing about an ounce. It melts and volatilizes, when protected from the atmosphere, at nearly the same temperature as zinc, but a fine wire or thin ribbon of it, exposed to high temperature in air, takes fire and burns with a bluish-white light of dazzling brilliancy.

Its light, as is now well known, exhibits properties not possessed by any other artificial light. By it the colors are all readily distinguished, and its actinic or chemical rays are so powerful as to have created an extensive demand for the metal from photographers, who find it desirable to extend their hours of business beyond those of daylight, or to

photograph objects in positions never reached by sunlight—as in the Mammoth Cave.

The attention of the writer was first drawn to this "new light" by a report of Prof. Piazzi Smith, the Scottish Astronomer Royal, regarding its use in the interior of the Pyramids of Egypt nearly two years since, and a further statement before the Royal Society that some apparatus was required for burning the magnesium steadily and economically. The first thought suggested was that it might be made useful as a signal light.

Experiments in this direction have been made in England, but with what success is unknown to the writer.

An experiment, conducted by an able army officer, to ascertain the comparative brilliancy of the magnesium light and the ordinary pyrotechnic signal lights, proved that a ball, weighing fifty pounds, of the latter material, was eclipsed in light-giving power by a ball of only one and a half pounds weight, of similar composition, to which had been added a small quantity of magnesium in fine powder.

Experiment has also shown the magnesium light to be superior to the lime light, and to compete with the electric light in brilliancy, while its cost is less than either.

Early in the present year the writer, then on duty at the Naval Academy, ascertained that Commander S. B. Luce, U. S. N., also on duty at that station, had devised an ingenious application of the Myers system of signals, which was remarkably well adapted to use with an arrangement of colored lights, and was already experimenting, as the writer had proposed to do, with lights of different colors, so arranged as to be exposed or hidden by the withdrawal or intervention of opaque screens.

The light used, however,—the ordinary ship's light,—had so little intensity as to make that system comparatively useless, although at short distances messages could be transmitted with remarkable rapidity.

It was apparent that the use of a light of sufficient intensity would render that system very efficient, and it was determined that experiments should be made with the magnesium light.

The apparatus formerly in use for burning magnesium was, in many respects, objectionable, but a new lamp was designed by the writer, subsequently improved by the American Magnesium Company, and this, the only kind now used in the United States, was used in these experiments.

An experimental apparatus was accordingly designed by the writer, in which one lamp burning magnesium was made to exhibit different colors as required; and with this experiments were, at first, made on shore.

These experiments proving successful, the apparatus was taken to sea with the U. S. Practice Squadron on the last summer, and while at sea Commander Luce made other experiments.

The vessels, between which signals were to be exchanged, were separated as far as possible, without being entirely hidden from each other by the convexity of the ocean, and messages of equal length

were sent each way, first by the magnesium light, then by the usual method of colored fires, and answers were returned.

The experiments proved that the magnesium light could be seen at a distance of eight miles or more with perfect distinctness, notwithstanding the fact that the light was somewhat obscured by the several thicknesses of glass interposed. To send the messages selected, required from six and a half to nine minutes by the magnesium apparatus and system, and about fifteen by the old method, although the latter had been somewhat improved by a device of Commander Luce.

The cost of the message was, by magnesium, *sixty cents;* by the old light, a trifle over six dollars.

Subsequent experiments in Chesapeake Bay were, if possible, still more decisively successful.

The appearance of the magnesium light at sea is that of a brilliant star; that of the usual light a bright flame. The common colored fire exhibits a greater volume of flame, while the magnesium has the advantage in intensity, in rapidity of the transmission of messages—by Commander Luce's system—and in its immensely less cost.

The magnesium may be packed in smaller compasses, and may be used in signaling so long as it lasts, while the lights now used occupy considerable bulk if carried in sufficient quantity for a cruise, give trouble in selecting correct numbers, and if a set corresponding to a single figure be exhausted, the whole stock is rendered useless until a supply of that set is obtained.

The chemical equivalent of magnesium being very low, 12·2, it suggests one reason for the brilliancy of its combustion, and also points to the probability that, by making up the common signal light with magnesium powder, an immense increase of brilliancy, as well as a reduced bulk, may be expected, and thus make them valuable for signaling from the mast-head at extraordinary distances, while the method above described will, from its economy, probably come into use in the naval and merchant services for signaling at moderate distances.

The English and French authorities, it is understood, are experimenting on magnesium with a view to its introduction into light-houses, and the result will be anticipated with much interest by seamen.

Naval Academy, Annapolis, October, 1866.

Cantor Lectures.—On Submarine Telegraphy. By Fleeming Jenkin, Esq., C.E., F.R.S.

From the London Journal of the Society of Arts, No. 690.

LECTURE II.

(Continued from page 230.)

6. *Statistics of Cables in Shallow Seas.*—The total failures of all kinds, in shallow water, excluding cables which had no proper outer iron protection, did not amount to 100 miles. About 2350 miles have been laid, which worked for some time, but are now abandoned. Of these, 1400 miles weighed less than one ton per mile, a weight which,

for shallow seas, is now known to be absurdly insufficient; these worked for about two years upon an average. 950 miles weighed more than one ton but not more than two tons per mile. The average life of these cables was five years. 5000 miles are now certainly at work; possibly more. They have already worked upon an average of four years and a half. They include one cable which has worked for 15 years, and several 13 years old; but the average is lowered by the long Malta-Alexandria and Persian Gulf cables only lately laid.—Every one of these cables, except the Malta-Alexandria, not originally designed for shallow seas, weigh more than two tons per mile. The interruptions on the lighter cables are somewhat frequent. On the Malta-Alexandria they have averaged four days per 100 miles per annum. Even this is not worse than the best land-lines in India, and is ten times better than the worst land lines in India.

7. *Maintenance and Returns from Cables in Shallow Seas.*—The average cost of maintaining the cables of the Submarine and Electric Telegraph Companies has been for some years from £8 to £9 per mile, excluding the cost of total renewals, which should be provided for by a reserve fund. The expense of the Malta-Alexandria repairs is not known. This line has earned as much as £3000 in one week, or at the rate of £117 per knot per annum. In one year the average earnings during the time it was open were at the rate of more than £90,000, or £68 per knot per annum; allowing for interruptions, the maximum earnings in one year were £64,000, or £48 per knot. The Persian Gulf cable is said to be earning at the rate of more than £100,000 per annum, or £85 per knot per annum. Neither cable has yet worked under favorable conditions; the former ends in a *cul-de-sac*, and the land-lines connected with the latter are so badly worked as to cause extreme delay and uncertainty. Such cables can be laid for sums varying from £300 to £400 per knot. The receipts on the Submarine Company's lines seem lately to have been at the rate of about £85 per knot of cable, or £26 per knot of insulated wire.

8. *Deep-sea Cables.*—Cables laid in less than 1000 fathoms would now hardly be considered as deep-sea cables, but formerly a depth of 300 or 400 fathoms was thought sufficient to entitle a cable to be put in this class, and the old classification has been adhered to in preparing the statistics of shallow sea cables. A cable to be laid in a deep sea must, of course, be strong, both absolutely and relatively, to its weight in water; it must be light, or the great lengths required cannot be conveniently carried; it must not be liable to stretch, and it must coil well and be paid out easily. At first, light specimens of the form already described as used for shallow seas were generally employed. The Red Sea cable is a fair sample. The first Atlantic cable is very similar, but the simple outer wires were replaced by strands of still smaller wires. The examination of Table IV. will show how far these cables met the above requirements. They could support from 4000 fathoms to 5000 fathoms of themselves, hanging vertically from the ship. They could be laid, and about 7000 miles of this class were laid, in depths approaching or exceeding 2000 fathoms, and these

cables have even, for a few miles, been hauled back from these depths. They seldom broke while being laid, but they were not permanently successful. Communication generally ended within a year from the time it was established, and the outer covering was then too much rusted to allow of repairs. The causes of failure were many,—but gutta-percha joints, bad copper joints, injuries to the insulator before the cable was laid, high battery power burning small faults into big ones and eating away the copper lining, from which they were often unprotected. These may be instanced as known causes of failure. It is also said some cables were laid too light, and sprung asunder when the iron wires rusted. It may be conjectured that when these wires rusted the gutta-percha could not bear the cable if suspended across a hollow. These are less probable causes of failure, but it is certain that the rusting of the outside and the failure of the cable generally coincided as to time. The failure was seldom gradual; it was almost, if not always, accompanied by a total fracture or interruption in the copper. When any of these injuries did occur, they were irremediable. The first important modification of the common form was to adopt steel wires instead of iron, reducing their number, and enveloping them in hempen strands, so as to produce a cable which externally looks like a hempen rope. Many excellent experiments were made on this form of cable (which was subsequently chosen for the second Atlantic) by Messrs. Gisborne and Forde, aided by Mr. Siemens. These experiments are given in full in Appendix 10 to the "Report of the Joint Committee on the Construction of Submarine Cables," published by government in 1861. The great strength, both absolute and relative, of this form may be seen from Table IV., showing that these hemp and steel cables will support 11,000 fathoms of themselves hanging vertically in water. The mass of steel required to cover the core is dimisished by the use of hemp, but as hemp is no lighter than water, it does not buoy up the wire. A steel wire simply wrapped up in hemp weighs much the same in water as a bare wire, and therefore wires, whether simply wrapped in hemp or bare, will support equal lengths of themselves in water, but the hemp may be so applied as to add all its strength to that of the steel, although the extensibility of the two materials is different. To do this, the hemp must be spun round the steel with a definite lay, to be ascertained in each case by experiment. Table VI. shows the strength of iron and steel strands wrapped with Russian and Manilla hemp, and with $\frac{3}{4}$ lay and $1\frac{1}{4}$ lay, respectively; also the strength and stretch of the separate materials. It will at once be seen that a difference of lay produces an extraordinary augmentation in the breaking strain and in the elongation. The stretch of a wire when approaching its breaking strain is concentrated nearly at one point, where it rapidly diminishes in diameter. The effect of the hemp is to support the wire at a number of successive weak spots of this kind, and thus greatly to augment the elongation before breaking; but it will further be observed that the breaking strain of the combined materials is actually greater in some cases than the sum of the strengths of the separate materials. Thus the sum of the manilla

TABLE VI.—*Compiled from Appendix 10 to the Report of the Joint Committee on Submarine Cables, (Gisborne, Forde, and Siemens.)*

MATERIALS.	BREAKING STRAIN IN CWTS.			ELONGATION IN PER CENTAGE OF LENGTH.			
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	No. of Experiments.
Steel wire 0·079 in. diameter	8·50	8·00	8·20	1·80	1·00	1·41	5
Iron wire 0·079 in. diameter	4·50	4·18	4·35	0·72	0·46	·55	7
Steel wire with four strands of manilla hemp, $\frac{3}{4}$ inch lay	9·25	9·25	9·25	1·77	1·77	1·77	3
Steel wire with four strands of manilla hemp, $1\frac{1}{4}$ inch lay	13·00	12·12	12·59	3·12	2·32	2·63	6
Steel wire with four strands of Russian hemp, $\frac{3}{4}$ inch lay	10·0	9·50	9·70	2·18	1·80	1·76	3
Steel wire with four strands of Russian hemp, $1\frac{1}{4}$ inch lay	11·75	10·87	11·42	2·70	2·28	2·45	5
Iron wire with four strands of manilla hemp, $\frac{3}{4}$ inch lay	4·75	4·50	4·62	0·79	·47	0·63	3
Iron wire with four strands of manilla hemp, $1\frac{1}{4}$ inch lay	8·50	8·12	8·28	2·80	2·56	2·62	4
Iron wire with four strands of Russian hemp, $\frac{3}{4}$ inch lay	5·00	4·75	4·87	0·92	0·66	0·82	3
Iron wire with four strands of Russian hemp, $1\frac{1}{4}$ inch lay	7·43	5·00	6·2	2·46	1·04	1·82	6
Manilla hemp weighing 0·05 lbs. to 0·0615 lbs. per fathom	3·87	3·62	3·75	....	....	2·62	2
Russian hemp weighing 0·41 lbs. to 0·45 lbs. per fathom	3·50	2·25	2·87	1·00	1·00	1·30	2

and steel, taking the mean strength, is a little less than 12 cwt.; but the mean of the combined strand is more than $12\frac{1}{2}$ cwt. With Russian hemp the sum of the separate strengths is 11·07 cwt., but the combined strand supported 11·42 cwt. The results with iron do not show this anomaly, but the apparant paradox with steel wire has been fully confirmed by independent experiments made for the Atlantic Telegraph Company. The explanation is, that when tested separately we have the strength of the weakest points, or smallest sections of the wires and strands; but these materials are never uniform, and when combined, as it is most improbable that the two weakest points should coincide, we obtain the sum of their mean sections or strengths. The cables formed by these hemp-covered steel wires are very strong. Table IV. shows that the Atlantic cable, relatively and absolutely, is the strongest cable yet made, bearing more than twice as great a length of itself as the old iron cable. The new form stretches more than the old. The hemp may be eaten off, or decay from the wires, weakening the cable, and the hemp affords less mechanical protection against injury; but the stretch is never such as to endanger the core, as has been proved by repeated experiments, and the most serious defect of the cable is probably its expense.

9. *Proposed forms of Deep Sea Cables.*—Rowett's hempen rope could certainly be laid. The lecturer has had no sample of it, but fears it would be extensible. Allan's cable could also be easily laid, so far as its strength is concerned. It is said to coil badly; but the lecturer has not seen this tested. The proximity of the copper and steel inside the cable might cause the steel to rust and burst the core. Still it is desirable that this form should be practically tested. Mr. Siemens' cable, also mentioned in Table IV., will be found described in the appendix to this lecture. The stretched hemp has great strength and elongates little, but has to carry an immense load of copper, which does not add to the strength of the cable. The phosphorized copper sheathing would probably be very permanent. This cable has actually been laid and is now working. A trial of it was not successful in deep water, but a piece was recovered from 1600 fathoms. Duncan's cable, covered with plaited ratan, is too extensible, and the ratan, though durable in water, does not add much tensile strength. The lecturer has had a sample of cable made, in which he used Siemens' stretched hemp, covered with Duncan's plaited cane. Its properties are given in Table IV., and its specification in the appendix. This cable combines great strength, small elongation, lightness, and cheapness. A bare gutta-percha core could be laid easily, but could not be recovered from great depths.

10. *Statistics of Deep-sea Cables.*—Excluding the 1000 miles in abeyance under the Atlantic, and the cable lost in the first experimental trips in the Atlantic, only some 500 or 600 miles of cable have been lost during laying. About 9000 miles have been laid and worked a little while, but are no longer working. From 700 to 850 miles are now at work, but much of this is in no great depth. The Barcelona-Mahon cable, believed still to work, although faulty, is included in

this list. There is but one quite sound cable lying at work in more than 1000 fathoms, viz: that between Sardina and Sicily, 243 miles long. One section of the Malta-Alexandria cable is in 420 fathoms, and has never shown any deterioration. The probable causes of failure have already been enumerated.

11. The general conclusions to be drawn from the statistics given in this lecture seem to be, that in shallow seas, by laying heavy, strong cables, we can insure, and have obtained, success, both from an engineering and commercial point of view; that in deep seas we have hitherto failed, but that success is not unattainable, and may probably be reached by several methods. The lecturer believes that, while in shallow seas, where repairs are possible, cables can hardly be laid too heavy or at too great an expense, in deep seas, where repairs will always be precarious, they can hardly be laid too light or too cheap.

APPENDIX I.—SPECIFICATION OF CABLES IN TABLES.

1. First Atlantic.—Core (*vide* Table III., last *Journal*, page 176) covered with 18 strands of 7 bright best charcoal wires 0·028 in. diameter, called No. 22. Total diameter 0·62 in; weight of iron, 15·64 cwt. per knot.

2. Red Sea.—Core (*vide* Table III.) covered with 18 bright iron wires (? charcoal), called No. 16, B.W.G., diameter, 0·77. Total diameter, 0·56 in.; weight of iron, 16 cwt. per knot.

3. Malta-Alexandria.—Core (*vide* Table III.) covered with 18 bright charcoal iron wires, each 0·12 in. diameter, called No. 11 (?). Whole cable, 0·85 in. diameter; weight of iron, 33·56 per knot.

4. Persian Gulf.—Core (*vide* Table III.) covered with 12 galvanized iron wires, 0·18 in. diameter, called No. 7½ (?); diameter of iron cable, 0 9 in.; covered with hemp and bituminous compound to 1·25 in. diameter; weight per knot of completed cable, 3·7 tons.

5. England-Holland Main Cable.—10 black wires, 0·375 diameter, called No. 00; external diameter, 1·58 inch; weight per knot, 10·4 tons; shore end 15 wires, 0·22, called No. 5, covered with 12 strands made of 3 wires of same diameter, covered with Bright & Clark's composition to 2½ inches in diameter; diameter of iron, 2 inches, and weight per knot, 19·6 tons.

6. Toulon-Algiers.—Core (*vide* Table III.) covered with 10 steel wires, each enveloped in four strands of Russian hemp. Diameter of steel wires, 0·08, called No. 14; diameter of strands about 0·2 in.; weight of hempen strands, (?); diameter of completed cable, 0·8 in.; weight in air, 1·31 tons.

7. Steel and Hemp-coated Gibraltar (proposed).—Core like Malta-Alexandria, covered with 12 steel wires in 4 hemp strands. Diameter of wires, 0·08; weight of steel per knot, 10·55 cwt.; of hemp, 6 cwt.; lay of hempen strands, 1¼ inch; diameter of completed cable, 0·875.

8. Iron and Hemp-coated Gibraltar (experimental).—Like No. 6, with iron instead of steel.

9. Second Atlantic Cable.—Core (*vide* Table III.) covered with 10 bright steel wires, each in 5 manilla hemp strands. Diameter of

each wire, 0·095 in., called No. 13; diameter of strand, about 0·28 in.; weight of hemp strands per knot, about 12·8 cwt.; lay of hemp strands, 3 inches. Webster & Horsfall's homogeneous steel.—Diameter of complete cable, 1·225; weight of steel per knot, about 13·75 cwt., and the serving round core about 2·2 cwt.

10. Siemens' Copper-covered Cable, (sample in Table V.)—Copper conductor, 550 lbs. per knot; insulator, 420; diameter of core, 0·52 in. Stretched hempen strands, 440 lbs. per knot; copper armor, 675 lbs. per knot; diameter of completed cable, 0·75 in.

11. Allan's Cable, (sample in Table V.)—Solid copper conductor, 0·114 in., weighing 240 lbs. per knot; surrounded by 19 steel wires, 0·02 in. diameter, weighing 120 lbs. per knot; diameter of steel strand, 0·16 in.; covered with 300 lbs. of gutta-percha, diameter 0·456, and canvas web; total diameter, 0·522.

12. Ratan and Stretched Hemp, (sample in Table V.)—Core, 363 cwt. per knot; diameter, 0·34 in.; covered with 15 hempen strands, weighing 1·84 cwt. per knot; and covered with plaited ratan cane, weighing 1·84 cwt.; total diameter, 0·625 in.

(To be continued.)

Self-acting Hydraulic Coal-cutting Machine. By W. E. Carrett, Eng.

Read before the Nottingham meeting of the British Association, Aug., 1866.]

From the London Civ. Eng. and Architects' Journal, September, 1864.

In the general detail of mining operations, the cutting away of the under portion of a valuable seam or bed of mineral to facilitate its subsequent removal, is at all times one of the most laborious and difficult operations, and is often effected by the miner under the greatest physical disadvantages; more especially when the seam of coal is very thin, and is cut on the "end" to improve its salable qualities. This "holeing," or "bareing," or "kirving," or "undercutting," is usually performed by about 40 blows per minute from a pick, handled with such experience as to cut 3 to 4 feet under, at the rate of 1 to $1\frac{1}{2}$ yards lineal per hour, and destroying much of the coal to make room for the operator, and enable him to work partly into the hole, to produce the requisite depth for a fall.

The speed and effort with which this picking tool is moved, combined with its weight, represent the power of one man applied in the shape of "percussive force," and this, under advantageous circumstances, is equal to about one-sixth of a horse power. The miner could not, with his limited power, force his pick, or any other shaped tool, into the coal as if he were cutting cheese; he is like the mechanic, who has to chip all his iron work with hammer and chisel, for want of a planing or slotting machine, and must reduce it by little as best he can, "in lieu" of suitable mechanical expedients to concentrate and apply power in a continuous, undeviating, and determined line. Yet the introduction of planing or slotting machines has not injured the mechanic, nor the morticing machine the joiner. There is ample work which the machine cannot do, and there are innumerable mines where

no machinery can compete with the skilled miner. To apply the power of horses in lieu of manumotive power, even though one horse is as powerful as six men, is practically very difficult. The power of both is dependent on the produce of cultivated lands ; and the fewer horses required the cheaper the necessaries for human sustenance.

There is yet a far more effective substitute for the power of both man and horse, which has been inviting our use for centuries, in the form of what George Stephenson conceived to be "bottled up sunshine." A coal-fed steam engine of one horse power is twelve times cheaper than one animal horse power, and our obedient servant for twenty-four hours daily, consuming the produce of uncultivated lands on which the sun shone ages ago.

Now, it is desirable that in many favorable circumstances this "undercutting operation of the miner should be accomplished indirectly by this steam power, and one of the practical methods of accomplishing this object is the subject of the present consideration.

If one collier had the power of say 18 men, and, when necessary, could make himself 2 feet high, and hold himself down upon the floor of the mine by pressing his head against the roof, and hold firm in his hands a kind of cheese scoop, in lieu of a pick, and could force it steadily into the coal at the necessary height from the floor, and to the required depth, he would then be exactly what is in many cases wanted. He would be a traveling morticing machine, and do more in one minute than 700 blows from a hand-wrought pick can do, and would, in fairness, demand a very stiff wage, which he would undoubtedly obtain.

This is what the iron man or hydraulic coal-cutter accomplishes. "He" is, if necessary, 2 feet high, has four legs, of adjustible length ; his head is also adjustable to touch the roof, and he weighs one ton. He is fed by a 2-inch flexible pipe, with sober drink, at 300 lbs. pressure, and at the rate of 30 gallons per minute.

This water pressure acts vertically on a 5-inch piston pressing against the roof, and horizontally on one about the same size, reciprocating 18 inches, and 15 to 20 times in a minute. There is a pressure of 5000 lbs. against roof, and the same pressure acting horizontally, forcing 3 "cheese scoops" into the coal. These cutting tools are 3 inches wide, and penetrate 4 feet, with a power equal to 3 horses or 18 men ; and this is effected by a consumption of 50 lbs. of coal per hour to feed the boiler of the engine, which makes the water pressure, and pumps the same over and over again. Thus this automaton iron man is dead-fast when forcing the cutters into the coal, and only requires to lower his head 1 inch at the return or back stroke, and advance, which he does also self-acting, at its termination, $\frac{1}{2}$ an inch to 1 inch, and then again he elevates his head and is ready for the next cutting stroke ; his sober veins being filled by incompressible if not exhilirating "water," and retained therein by a keep-valve for the necessary time, enabling him at that moment to defy the roof to crush him. This self-acting hydraulic coal-cutting machine, or "iron man," which has now been two years at work, is the miners' best friend.

It does not dispense with his labor, but performs for him the undercutting, a most laborious operation, either in the end or face of coal, and in a more efficient and economic manner than he can do it himself. The coal so operated upon by the machine does not fall forward when becoming detached from the roof, but settles on the lower bed, thereby avoiding serious accidents. The saving in coal alone more than pays for the outlay; and it is practicable to cut with the most perfect ease into the floor of the mine, thus preventing all waste of coal whatever. The size of the coal is improved, the amount of slack is considerably reduced, and a single seam will yield more by one thousand tons of coal per acre, than when worked by hand labor in the usual manner.

The machine undercuts "holes," or "kirves," with a man and boy as attendants, and completes the work with once going over, at the rate of fifteen yards per hour, and at any angle and height from floor or rails, being suitable for either "dip" or "rise" workings, and is capable of cutting the thinnest seams. The pressure of water which actuates this apparatus can be obtained either from the stand-pipes in the pit, or from pumps attached to any existing engine, or from an engine and pumps specially made for the purpose. The quantity necessary is only what is sufficient to fill the circuit of the pipes, using it over again when desirable, as in the Bramah press. Any idea of a large volume of water being necessary may therefore at once be dispelled. There is also no leakage whatever.

Each machine uses thirty gallons per minute, at about 300 lbs. pressure, according to the hardness of the coal or mineral to be operated upon. In cutting the shale of the Cleveland ironstone band, a somewhat greater pressure is found to be necessary. There is no limit to the pressure of water that may be used, nor the distance it may be forced without loss of power, beyond that due to its friction along the pipes. The same water pressure is also applicable to work pumps and rotative engines for hauling, &c., and other requirements in the mine, at a distance from the engine power. In cases where there is a fall of water, say of 100 lbs. pressure, it can be "intensified" by a self-acting machine to 400 lbs. pressure, to work the coal-cutter, but sacrificing three-fourths of the bulk, which is thereby set free.

The water is supplied in a continuous stream; it is, in fact, the medium through which the mechanical power is applied direct from the first coal-fed motor, (a steam engine and pumps,) in lieu of the usually developed power derived from vital energy, and applied to the handle of a pick, effecting the desired object by a series of percussive blows or impacts. The power of six men is equal to one horse, and is six times more costly; and the power of one horse steam motor, or engine, is eighty times cheaper than six men. The machine is about three horse power, and weighs one ton, and will work either right or left. It is self-acting in all movements, and will ascend the steepest gradients. Being simple in all its parts, it is not liable to get out of order, and is easily managed by an ordinary miner, and transported from place to place, on the ordinary rails, about the mine.

Although the length of stroke of each cutting tool is eighteen inches, the practical cutting length is sixteen inches, and, consequently, the three cutters jointly give a total effective depth of four feet at each stroke of the machine, finishing the work as it goes along. The mechanism employed consists of an hydraulic reciprocating engine, adjustable to any height and angle, having a self-acting valve motion. The cylinder is four and a half inches diameter, and lined with brass, and the piston made tight with ordinary hydraulic leathers, easily renewable. Within the piston-rod is attached the cutter-bar of steel, carrying the tools or cutters. These can be varied in number to suit the depth to be holed at one operation. The cutting tools are of double sheer steel, easily made, and very strong, and can be removed and replaced in a few moments; they are readily sharpened on an ordinary grindstone. The cutter-bar is also removable, when transporting the machine from place to place, for which purpose the main cylinder is, for the time being, placed longitudinal with the rails.

The machine in operation fixes itself dead-fast upon the rails during the cutting stroke, and releases itself at the back or return stroke, and traverses forwards the requisite amount for the next cut, without any manual labor. Should the tools be prevented making the full stroke at one cut, they will continue to make more strokes at the same place, until the maximum depth is attained, when "only" the machine will traverse itself forward the required amount for the next cut. Thus, at one operation, a uniform straight depth is attained, parallel with the rails, inducing an even fracture when the coals are brought down, and thereby a straight line for the new coal face. There is no percussive action, either against the roof or into the coal, but simply a concentrated pressure, producing a steady reciprocating motion, at fifteen strokes per minute. There is, consequently, no dust or noise, and little wear and tear. For the same reason, when cutting pyrites, the tools throw out no sparks, and the workman can hear any movement in the coal or roof.

The required height from the line of rails in the "holeing," "kirving," or "bareing" varies in different mines. It follows that the hydraulic cutting cylinder, and its direct action cutting tools, have sometimes to be arranged above the carriage, and sometimes beneath the main carriage, or close down upon the rails.

Traction Engines.

From the London Journal of the Society of Arts, No. 721.

A train drawn by a locomotive on the common roads has recently arrived at Paris. The following details will be read with interest: The locomotive has a tubular boiler, carries a tender, a water-tank, and foot-plate in front of the engine. The engine is on the top of the boiler; it has two cylinders, with reversing gear. It is worked from the front by means of a guide-wheel, which is moved by one man; it works with ease and perfect regularity; it can turn in curves of a very small radius, and can follow all the windings of the road. This engine, travel-

ing on a level road, or on one that presents no gradients of more than three per cent., draws an actual load, after deducting the weight of the wagons, of 12,000 to 15,000 kilos., or from twelve to fifteen tons, at a speed of four to six kilometers, or from $2\frac{1}{2}$ miles to $3\frac{3}{4}$ miles per hour. It draws at high speed, that is to say, 14 to 16 kilometers per hour, or nine to ten miles, a clear weight of 1000 to 4500 kilograms, or from one to four tons and a half. The wagons are coupled one to another as well as to the locomotive, and by a mode of coupling which allows them to follow all the movements of the engine, however much it may deviate from the straight line. The engine stopped at a great number of places on its journey from Nantes to Paris, in order to satisfy the public curiosity.

The Festiniog Railway.

The following discussion was elicited in the Institution of Civil Engineers, of Great Britain, by the reading of an article by Capt. Tyler, R.E., on the Festiniog Railway, which may be found in the *Civil Engineer and Architect's Journal.* The article itself does not present any especial interest to us, and we omit it; but the discussion is so full of facts which will interest and may benefit our engineers, that we republish it for their benefit:

Captain Tyler said: Having been called upon officially to inspect this railway, he thought a brief description of it might be interesting, and he hoped that description would be the means of calling forth a discussion of great use, in elucidating the important question, whether it was desirable to have a narrower gauge in this country, under peculiar circumstances of locality, and having regard to the nature of the traffic. There were already in Wales a number of different gauges used on tramways for bringing slates and minerals down to the ports of shipment, and in other countries different gauges were springing up. In Queensland, he had been informed, one hundred miles were in course of construction on the gauge of 3 feet 6 inches, and two hundred miles more were projected on the same gauge. It was important to ascertain, what would be a suitable gauge in those instances where the traffic was not likely to be large. Farmers were now using portable railways for transporting the produce of their fields, for bringing their harvests, spreading manure, &c., and there seemed no reason why districts, which could not support a railway on the gauge of 4 feet $8\frac{1}{2}$ inches should be altogether deprived of the advantages of railway communication. The question of gauge was, in one sense, a question of speed. Speaking roughly, on a railway of 2 feet gauge, with 2 feet driving-wheels, traveling might be made as safe at twenty miles per hour as on the Great Western, with its 7 feet gauge and 7 feet driving-wheels, at seventy miles per hour. He had traveled on parts of this little line at the rate of thirty miles per hour with every feeling of safety. He regretted the unavoidable absence of Mr. Spooner, because it prevented him thanking that gentleman, in the presence of the meeting, for the information afforded during the preparation of this paper, and because, if

he had been present, he would have been able to give further information on the subject. Mr. Spooner took great interest in this line, and was accustomed to travel on it along the Traeth Mawr embankment in a boat carriage, not inappropriately named "Ni l'un ni l'autre," being carried along by a sail. The preliminary expense in first applying locomotive engines, and making numerous adaptations on so narrow a gauge, were considerable; but since the line had been in working order, the following results were shown:

Statement of the comparative cost of working the Festiniog Railway by horses and by locomotive power.

BY HORSES.

	£	s.	d.
Contract for the carriage of slates and minerals, 70,000 tons at 8*d*., the contractor finding labor, grease, and oil	2333	0	0
Contract per ton on 9000 tons of coals, train, and other merchandise, ditto, at 3*s*., the draft being ditto, less journey	1350	0	0
No passengers, and no cost for porterage			
	£3683	0	0

BY LOCOMOTIVES.

	£	s.	d.
Locomotive department (wages)	740	0	0
Materials for repairs of locomotive tender and van	200	0	0
Fuel, oil, and grease required for working traffic, including oil for signal lamps, &c	636	0	0
Additional expenses and wages, keeping train in repair, over above amount by horse power	296	0	0
Additional cost in keeping up permanent way	680	0	0
Additional attendance in signal men on the horse system	334	0	0
Cost of working train by locomotive	2886	0	0
Cost of working train by horses	3683	0	0
Difference in favor working by locomotive nearly 22 per cent...	£797	0	0

Mr. G. W. Hemans said he had seen this railway, when worked by horse power, about three years ago, and was glad to hear now that it confirmed the impression he then entertained, that the project of working it by locomotive power would be successful. The idea of using locomotives arose from the competition branch line, which was contemplated by the owners of the ordinary gauge lines, leading along the Welsh coast, and which branch was to penetrate into the slate district. He was called upon to examine as to the propriety of this branch line on the ordinary gauge, for the purposes of the slate quarry, and the result of his observation was, that for those purposes that gauge was unsuitable, and that no better thing could be devised than the existing 2 feet gauge. The small wagons on this gauge were carried over steep inclinations of 1 in 12 and 1 in 15, and in some places of as much as 1 in 5, or in 6, so as to penetrate into every part of the immense slate quarries of Festiniog. The slates brought down on these extensive ramifications were expected, if the ordinary gauge branch were constructed, to be delivered at the foot of the inclines, to be there gathered together, and the narrow wagons would be hoisted into broad gauge wagons and taken to the port. This would clearly have proved

a great inconvenience, and the project of using locomotives on the 2 feet gauge, as far as the foot of the steep inclines, seemed so feasible that he gave it his warm support, and the consequence of the opposition to the broad gauge branch was that it was withdrawn, and the project of working the narrow gauge by locomotives was carried out. He thought the attainment of a fair speed by the narrow gauge locomotive was, to a great extent, as safe as on the broad gauge, provided the wheel base was properly proportioned to the engine. With regard to the economy of the working, another question arose. As to the general principle, whether it was desirable to encourage very narrow gauge lines in positions of this kind, it depended upon the nature of the traffic. He doubted whether that system could be extensively used for passengers; but where there was a large amount of mineral traffic coming out of narrow galleries, all going in one direction, and but a small passenger traffic, going in either direction, he had no doubt a system of narrow gauge railways might be advantageously adopted. He thought it a matter worthy of legislative inquiry, whether this system might not be beneficially extended upon some well-considered gauge. At the same time, as a general principle, there was great objection to alteration of gauge. As regarded Ireland, the adoption of the gauge of 5 feet 3 inches had not produced beneficial results.

Sir Charles Fox remarked that he had had a great deal to do with railways of various gauges. It was a subject to which he had given more attention than perhaps any other. He thought break of gauge was a serious matter, and yet it was difficult to say there never should be break of gauge. As joint engineer of the Indian tramway, with regard to which line a question arose as to what gauge should be adopted, he wrote a long report, in which he advised that that company's lines should not be made tramways, but light railways; and as in almost all cases such lines would be tributary to main lines, the gauge of which he believed was 5 feet 6 inches, he advised that the tributary branches should be laid to the same gauge; but he coupled that advice with what he thought was an important condition, which was, that the load upon each pair of driving-wheels of the engine to run on such lines should be limited to the greatest load that could by possibility come upon any pair of wheels in a train. He calculated 6 tons on each pair of wheels, and he did so for this reason: he considered that the tributary lines in India, if intended to pay, ought to be worked by the rolling stock of the parent lines. All the rolling stock of the parent lines, except the locomotives, might with safety be carried on rails of not more than 35 ℔s. to the yard; but there must be locomotives of not more than about 18 tons on three pairs of wheels, or if of 24 tons, on four pairs of wheels, thus equalizing the total load by placing 6 tons on each pair of wheels. But whether the gauge was 3 feet 6 inches, 4 feet 6 inches, or 5 feet 6 inches, the rolling stock need not be comparatively heavier in proportion to the greater width of the gauge; and if the weight were restricted to 6 tons on each pair of wheels, the light permanent way would be able to do the work. The report to which he alluded, after being considered by the direct-

ors, was not acted upon. The line between the Arconum and Conjeveram, forming a junction with the Madras main line, was of the gauge of 3 feet 6 inches; but since then the governments of the three presidencies came to the determination that no tributaries to main lines should in future be of any other gauge than 5 feet 6 inches, the only condition on which a narrower gauge was to be permitted being where the line was not tributary to a main line, and even that, he believed, was not yet fully determined upon. His own opinion was, that the government would adhere, in all cases, to the resolution requiring the gauge of 5 feet 6 inches. On the other hand, the objection to a uniform gauge for both main line and tributary branch was, as alleged by the managers of the companies, that they had no proper control over their servants, and that if a man was accustomed to drive an engine of 30 tons on the main line, he could, if he chose, run the same engine on to the lighter road, very much to its injury; whereas, having a different gauge effectually prevented this being done. He thought that there should be no separate establishment for the repair of those engines, but that all the locomotives should be the property of the parent company. The engines could then go to the same shops to be repaired, which would be a convenient and economical arrangement, particularly on a short branch. On the line to which he had referred, he had been obliged to send out all the tools necessary for the repair of the engines of 3 feet 6 inches gauge, whereas if the gauge of 5 feet 6 inches had been adopted, arrangements might have been made for the whole of the rolling stock to be repaired by the parent company, under an agreement with the branch undertaking. He thought it was more important to limit the weight on the driving-wheels than to fix any particular gauge, the latter being a matter which must be determined by the circumstances of each case. After a good deal of consideration on the subject, he thought if he had now to establish a gauge to be used all over the world, he should fix it at 5 feet 4 inches. The Irish gauge of 5 feet 3 inches was a very good gauge. The Indian gauge of 5 feet 6 inches was also a good gauge, but it necessitated a rather heavy rolling stock, while the gauge of 4 feet 8½ inches was in his opinion too narrow. At the same time, unless there was some strong reason for departing from the universal gauge of any country, he would follow out that gauge in even the light tributary lines.

With respect to Queensland, the government of that colony had decided beforehand upon making its lines on the gauge of 3 feet 6 inches, and the plans were referred to him for confirmation. More than 100 miles were now being constructed, and authority had been obtained for 200 miles or more, the "matériel" of which was now being prepared. In the case of the Indian branch of 3 feet 6 inches gauge, all the "matériel" and rolling stock had been sent out from England, the sleepers being of teak. The line was laid upon an old road, which was granted to the company by the government, and which required some alterations in its curves and gradients. The total cost, including rolling stock, would be not quite £3500 a mile.

With regard to the radiating axle-boxes referred to in the paper, and which had been adopted for sharp curves on the Norwegian lines, he was so satisfied with them that he was sending such boxes out to Queensland. He believed that, on the Queensland railway, 5 chains was the sharpest curve, and that 1 in 40 was the steepest inclination; that the weight of the rails was 40 lbs. to the yard, and that the engines with six wheels did not exceed 15 tons in steam, ready for work, exclusive of their tenders, carrying fuel and water.

The most important reason for using the narrow gauge, in this instance, was for the construction of circuitous lines through mountain ranges, where it was impossible, except at very great cost, to have curves of long radius. If it had not been for the sharp curves, he would not have recommended the narrow gauge for the Queensland lines; and it must be borne in mind that these, being the first railways in that colony, there was no existing gauge to which the gauge of these lines had to be adapted. He hoped, however, that his remarks did not lead to the supposition that he would lay down a railway, with a gauge 5 feet 6 inches, to a slate quarry in Wales. His observations applied only to such lines as were tributary to main systems of railways.

Mr. Peter Bruff remarked that all the Norwegian lines alluded to were isolated. The original line made by Mr. Stephenson and Mr. Bidder had been extended to the confines of Sweden, and was entirely constructed on the gauge of 4 feet $8\frac{1}{2}$ inches, with which the other lines of the country were never likely to be brought into communication. Radiating axle-boxes, he understood, had been recently introduced on the Norwegian lines with considerable success. The weight of rails generally adopted was 37 lbs. to the yard, laid in lengths of 21 feet, the rails being flat-bottomed, $3\frac{1}{2}$ inches high, with a base of 3 inches, laid on cross sleepers, and fish-jointed. In some cases, a plated joint had been used, which, from the experience obtained in England, was not considered a desirable arrangement. Upon the subject of narrow gauge Norwegian railways, he had, however, received a communication from Mr. Pihl, who, in 1856, was entrusted by the Norwegian government with the task of supplying railway communication between Throndhjein (about 350 miles northward of Christiana) and Storen, the point from which two main carriage roads ran south, and between Hamar, on the Lake Mjosen, about 56 English miles north of Christiana, (with which it was in direct communication by rail and steamer,) proceeding eastward to Eleverum, upon which the traffic of the Glommen valley converged. Mr. Pihl stated that he determined, from the difficulties of the country and the smallness of the traffic to be accommodated, that he should not be justified in recommending such an outlay as would be involved by the formation of a railway as ordinarily constructed. He therefore recommended a gauge of 3 feet 6 inches. This was adopted by the government, and confirmed by the legislature (Storthing) in 1857, and shortly afterwards the works of both lines were proceeded with.

The works upon the Hamar line, being the more easy of construction,

were sufficiently advanced to be used for goods traffic in the summer of 1861. The total cost of this line, for 24½ English miles, had amounted to about £3000 per English mile. This included a large iron bridge, on stone piers, about 900 feet long, for ordinary road purposes only. The rolling stock of three locomotives, six passenger carriages, three break vans, and fifty goods wagons, with the necessary ballast wagons and tools for repairs; also two terminal stations, and six intermediate stations and stopping places, a carriage shed, and a small repairing shop. Although the works were not of a heavy character, there were, nevertheless, many difficulties to contend with, the lines having to ascend upwards of 400 feet, and to cross extensive and deep swamps.

The Throndhjein line of 31½ English miles, running through a difficult country, required many heavy works of construction, among which were numerous large bridges, some being from 70 feet to 100 feet high, several cuttings containing from 50,000 cubic yards to 70,000 cubic yards each, and others through rock of more than 30 feet in depth. The cost of this line was necessarily greater than the former, in all about £5000 per English mile, including four engines, eight passenger carriages, three break vans, sixty goods and plank wagons, besides twenty ballast trucks, with the necessary implements for the repairs. There were besides the terminal stations, six intermediate stations and three stopping platforms. At Throndhjein there were also goods and carriage sheds, and a workshop for the repair of the rolling stock. This line had to cross a ridge more than 500 feet in height, in the first Norwegian mile from Throndhjein. The greater part of this distance was constructed on one side of the ridge with gradients of 1 in 42 and 1 in 65, and on the other side of 1 in 52, the curvature being of about 900 feet radius; whereas, on the other portion of the line, where the gradients were seldom more than 1 in 100, curves of 750 feet were frequently resorted to. The width at the formation level in cuttings and on embankments was 13 feet nearly. The slopes, according to circumstances, were from 1½ to 1 to 3 to 1. The ballast was 8 feet wide at the top, and 1 foot 9 inches in thickness. The sleepers were of half-round pine, 6 feet 6 inches long, placed 2 feet 6 inches apart on the curves and steep gradients, and 2 feet 9 inches apart on the straighter portions of the line. The rails were flat-bottomed and fished at the joints in the usual way, 3¼ inches in height, and weighing 37 lbs. per yard, except on the steep inclines, where rails of 41 lbs. per yard were laid. The rails were fastened to the sleepers by dog-spikes only, no bolts or bottom plates being used. Ransome's chilled crossings, and Wild's self-acting switches were used throughout. The bridges were all of timber, except where large rivers had to be crossed, and spans of from 50 feet to 100 feet were required, in which case stone piers were carried up above flood-level. The superstructure made use of in those cases was Howe's system of trellis work, with iron suspending rods. The rolling stock consisted of tank engines with three pairs of wheels, two pairs being coupled for drivers, these having an available weight for traction of from 11 tons to 15 tons, out of the 14 tons to 15 tons, the total weight. The last engines procured were provided with

bogies on Bissel's or Adams' system. The cylinders were 10 inches in diameter, with a length of stroke of 18 inches, and the driving wheels were 3 feet in diameter. All the engines were made in England, with the exception of one made at Throndhjein, and were working efficiently. The passenger carriages were constructed to carry the usual number of passengers, as in England, and were arranged for two classes only, the compartments being fitted up as first and third. The goods wagons were made to carry 5 tons, and were only a few inches narrower than the ordinary kind, these widths being obtained by having the springs attached to brackets inside the sole bars, thereby allowing the lowering of the body and, in consequence, the centre of gravity. The buffers were all central, and 2 feet 6 inches above the rail-level, and served also as draw-bars. The couplings on those last constructed were self-acting when the wagons were brought together. As this narrow gauge allowed a correspondingly larger wheel-base than the ordinary gauge, the wagons ran very steadily. Some of the wagons were constructed to carry planks 24½ feet long, and had a length of wheel-base of 13 feet.

The usual rate of speed was about 15 miles per hour, including stoppages, and the trains ran quite as steadily on this line as on the broader gauges. The traffic on these lines, though considerably below that of the lowest of the English lines, had already fully paid the working expenses, while the impulse given to the development of the resources of the country must undoubtedly, in course of time, produce a corresponding and satisfactory increase of revenue.

In order to show the economy of construction, Mr. Pihl mentioned that, simultaneously with the construction of these lines, an extension of about 50 English miles were constructed, from the old trunk line built by Messrs. Stephenson and Bidder in 1850–53 to the Swedish frontier, of the ordinary gauge of 4 feet 8½ inches, the cost of which was about £6400 per English mile, the rate of wages and the class of work being, as nearly as possible, of the same description.

In addition to the two narrow gauge lines described, there was in course of construction another line of the same gauge, between the town of Drammer and the Lake Randsfjorden, about 57 English miles in length, besides several branch lines in preparation. None of these several lines would ever have been made had not the small cost justified and encouraged the undertakings.

Mr. Pihl added that, last summer, Mr. Charles D. Fox inspected the narrow gauge lines in Norway. All the details, with the engines and rolling stock, were unreservedly placed at his disposal; and on leaving he wrote: "With reference to the interesting question of the 3 feet 6 inch gauge, I shall return convinced of the thorough efficiency of such a gauge for the purpose of a new country, and of the wisdom of adopting such a gauge where the traffic is not very heavy."

Mr. Phipps inquired, whether the economy of these narrow gauge lines did not consist chiefly in the diminished cost of construction, rather than in working the traffic of the line? In his opinion, the cost of haulage per ton could not differ much, whatever the gauge might be; but as regarded the construction of the line, it would, of course,

be less for the narrow way. These narrow ways were obviously suited for mountainous districts, where, the curves being necessarily sharp and frequent, it became important to reduce, as much as possible, the friction arising from wheels keyed fast upon the axles, which was obviously done by diminishing the width of gauge. On tolerably level ground, with the ordinary alternations of cutting and embankment, where the slopes formed so large a proportion of the whole earthwork, the saving from narrowing the gauge would probably not be considerable.

Mr. Bruff replied that, though considerable economy in the earthworks arose by adopting sharp and reverse curves on the Norwegian lines, the bridges and viaducts were extremely heavy, so much so as to have astonished him when he was informed of the prices at which the lines had been carried out. No doubt, the economy of construction was greater than if a heavier rolling stock and permanent way had been employed throughout.

Mr. Gregory, V.P., remarked that, with the narrow gauge, a shorter wheel-base of the engines could be adopted, which gave greater ease in traversing sharp curves.

Mr. Robert Mallet said, as yet no mention had been made of another narrow gauge line, which had been a long time in successful operation, viz: that between Antwerp and Ghent, the gauge of which, he believed was only 2 feet 3 inches. He could not give the precise particulars of the rolling stock, but could state, generally, that the carriages were wider than those on the Festiniog Railway, and they carried heavier loads.

The subject of narrow gauge lines was not new to him. About eleven years ago he recognised the advantages in respect of cheap railways and traffic, which would arise from narrow gauge lines; and in 1855 he had proposed to Mr. Hemans a line along the north shore of the Bay of Dublin to have a gauge of only 2 feet 6 inches. That project, for reasons it was not necessary then to go into, was not carried out. A bill, however, was presented in the present session of Parliament for a similar line, and he hoped it might be made on the narrow gauge. In viewing the question of narrow gauge and ordinary gauge railways, it was necessary to consider what he might call the prudential considerations, those that related to the circumstances of traffic, &c., separately from those which were of a purely physical character. He met in Sicily last year Colonel Yule, late of the Bengal engineers, and he had had many opportunities of discussing with him what had passed relative to Indian tramways, or ranch railways. Colonel Yule's opinion was decidedly in favor of narrow gauges, and he considered that in India it was simply a question between the bullock-cart, or these narrow gauge lines, as feeders to the trunk lines. Reverting now to the purely physical considerations, it appeared to him, as a physical necessity, that, not only the original cost of two similar lines differing in gauge, but also the cost of working them, would approach the ratio of the cube of the length of axle, or, what was the same, of the breadth of gauge. A little consideration would show that, however startling, this proposition, without having any pretensions to be a mathematical truth, was never-

theless, approximately true. As an illustration of this, if the axle of a carriage, as a cylindrical shaft, exposed to cross-strains, were taken, it would not admit of dispute, that for equal strength, on different gauges, the diameter must vary as the cube of the length, or of the gauge. Therefore the weight of the axles would be in the ratio, and so must be that of the wheels to carry them. Then as to the carriages: as it was equally undeniable that the weights of any similar structures whatever, varied as the cubes of their homologous dimensions, so the weight of the carriages would be as the cubes of the gauge, if the carriages were of equal lateral strength: and the axles and wheels must be proportionate to carry this load. In a word, all the rolling stock would be increased in something like the ratio of the cube of the gauge. If this were so, it followed that the permanent way itself must be increased in a proportionate ratio to bear that load; and if it were true, that the cost of haulage was a function of the weight drawn, it equally followed that the rolling expenses, or those for working the line of road, would be about in proportion to this increased weight of rolling stock also. He wished to guard against being mistaken as now speaking mathematically, or as using the cube as a precise expression of the relation. His intention was merely to illustrate the proposition, which he deemed generally true, that not only the first cost of construction, but also the expense of working railways, increased with the width of the gauge, but in a greatly higher ratio, or, in other words, that in proportion as the gauge was reduced, both the first cost and the working expenses would be diminished. There were some special physical advantages in narrowing the gauge; for example, engines or carriages could go round a sharp curve more easily with a 2-feet gauge than with a 7-feet gauge. This fact had had some doubt thrown on it, but its truth was obvious, from the consideration that, if the two rails could be brought close together, or into one, there would be no longer any resistance at all in going round, due to the outer and inner wheels having to go over different lengths of curve in equal times.

Mr. Savin said, he had not at first imagined that a line of so narrow a gauge as the Festiniog Railway could be worked successfully with locomotives; but he had traveled on that line both with locomotives and in the boat carriage, and he thought it a great success, both in regard to its adaption to the circumstances of the locality and in its commercial results. He agreed that the gauge of railways in any one country should be uniform, as far as through systems of working were concerned; but, having had some experience in Wales, he thought it impracticable to carry out the broad gauge in that country. He had seen various gauges in operation, from 2 feet up to 3 feet 6 inches. His own feeling was in favor of 2 feet 3 inches or 2 feet 6 inches, where the valleys were crooked and steep-sided. In this way many physical difficulties might be avoided, by the adoption of curves of shorter radius; a 2-feet gauge line might be fitted to the contours of the hill-sides, in such a manner as to reduce the cost of railway communication to a minimum. A line 16 miles long, for which he had given £20,000, was laid on the gauge of 2 feet 3 inches, and that line

had been extended into a district similar to that which the Festiniog Railway passed through. There would have been very little chance of carrying a bill for a railway on a gauge of 4 feet 8½ inches in that district, and the result would have been, that, but for this class of railway, the present development of the mineral resources of those valleys would not have been attained; and it was especially with reference to districts such as this, that the subject was worthy of the fullest consideration on the part of engineers.

(To be continued.)

Unsinkable Vessels. By Jas. Parker.

From the London Mechanics' Magazine, April, 1866.

As the late catastrophe has called public attention to the dangers of ocean-traveling, will you allow me space to explain a plan, which, if adopted, would render every kind of vessel perfectly safe from foundering? When any part of a vessel gives way and admits the water, the usual remedy is to pump it out as quickly as possible, either by manual power, or, in case of steamers, by steam power, and great importance is often attached to the power of steam pumps, which, however, are often found useless in the hour of danger. Supposing a serious leak to have occurred, then follows the fight of the crew and passengers for life against the enemy. At one time the crew may gain a little, and at another the water gains a slight advantage; and unhappily this miserable and exhausting battle is not by any means an uncommon occurrence. It seems to me that the whole system of endeavoring to keep down the water by any kind of pump is radically wrong in principle, for by pumping out the water space is left for more to come in. The true remedy is to pump air into the vessel, whereby each gallon forced in becomes a clear gain to the stability of the vessel, and leaves so much less space for water to occupy. A very little exertion in this way would soon render a vessel of 1000 tons perfectly safe from foundering, without reference to the size of the leak, which might increase sufficiently to let the engines and boilers fall through the bottom of the vessel, without in the slightest degree adding to the danger of the vessel's sinking.

I therefore propose that all passenger vessels should be compelled to carry such a number of air-tight flexible bags as, when inflated in the different parts of the ship under the decks, would by their bulk prevent the vessel from sinking, even if the water had free access. The expense would not be a very large item, and nothing in comparison with the value of the sense of security to the passengers, and, therefore, of higher passage money. An iron vessel without compartments, laden with stone or iron, if protected in this manner, would be just as safe from sinking by having a hole knocked into her bottom as a timber laden ship. The bags, of say from twenty to fifty or more gallons, could be kept permanently filled with air in all vacant spaces of the

ship not required to be visited during the voyage, and, upon the appearance of danger, other bags could be inflated in proper positions in the cabins or elsewhere, until the bulk occupied was more than sufficient to support the ship. A bump on the rocks, leaving a large hole in the ship's bottom, provided the vessel did not break up her decks, would not then be of any great moment. In the case of steamers the bags could be filled by air forced by the steam in a few minutes.

In some experiments lately tried on the Thames in propelling a large boat with air, without machinery, I forced into the water, by aid of the steam from a one horse power boiler, about 1000 gallons of air a minute, and obtained a speed of three miles an hour through the water. If the *London* had been properly fitted upon the above plan, the steam from the boiler of her donkey engine would have rendered her perfectly safe from foundering in a few minutes.

MECHANICS, PHYSICS, AND CHEMISTRY.

On the Supposed Nature of Air prior to the Discovery of Oxygen.

By George F. Rodwell, F.C.S.

(Continued from vol. l., page 346).

From the London Chemical News, No. 316.

XIV. *Rise of Pneumatic Chemistry.*—We can scarcely be surprised that the air received but little attention till a comparatively late period in the history of the world, when we remember that there existed no means of ascertaining even its most salient properties. Inquiries into the nature of an intangible and invisible body, which exercises no apparent effect upon the matter around it, belong to a somewhat advanced stage of experimental philosophy. They require the assistance of a large amount of collateral knowledge, of a refined manipulation, of a mind tutored in the mode of physical thought, and used to the classification of diverse phenomena. The most obvious property of matter is its visibility, and the conception of it divested of that property is no small effort to an ordinary mind. We all know the invariable wonderment produced at a popular lecture when carbonic acid is poured upon a lighted taper, or when hydrochloric acid gas and ammoniacal gas are brought into contact. When we call to mind the ideas which obtain among the unscientific in the present day in regard to gaseous bodies, we cannot wonder that so little was formerly known of the air.

The ancients, although they classed air among the four elements from which they conceived the world had been produced, had no definite idea of its nature. Many philosophers doubted whether it were material, and the great mass of the people scarcely recognised its existence. The fact adduced to prove its materiality (the simplest and most obvious that could occur to the mind) was that it could be felt when in motion, viz: as wind. Anaxagoras went a step further, and urged as an additional proof (*a*) that a blown bladder resists com-

pression, and (*b*) that an inverted drinking vessel, when plunged beneath the surface of water, is found to remain perfectly dry inside, which would not be the case, he argues, unless something material had prevented the ingress of the water. But these crude experiments merely proved that the air is matter.

Then, again, the experiment of burning a candle in a closed vessel standing over water, could throw no light on the nature of the air, as it could not be rightly explained in the then state of science. It may be considered the earliest experiment in pneumatic chemistry; it is mentioned by almost every Middle Age writer on alchemy and chemistry, but scarcely two give a similar explanation of the phenomena observed. Nor is this to be wondered at, when we remember the amount of chemical knowledge required for its explanation. To explain it in its entirety it was necessary to know (*a*) that the air is composed of two gases; (*b*) that they are insoluble in water; (*c*) that during combustion one of them unites with the burning body; (*d*) that a gas soluble in water is the result; (*e*) that the other gas cannot unite with the burning body; and (*f*) that in a known volume of air there are four volumes of the latter gas to one of the former. No wonder the experiment puzzled the scientific mind for so many centuries. No wonder it became a habit to fasten a pet theory upon it, or to propound one specially for its explanation. Those old philosophers, who with difficulty spun out a page or two about it, little thought how much was linked with the true explanation of the experiment, how their ponderous and unwieldly theories, upon which so much thought had been expended, so little experiment, would have disappeared utterly; how the face of science would be changed when a new race of thinkers, working slowly and laboriously, were destined to elucidate each phase of the experiment.

But although this experiment remained unexplained, it proved to the more observant the important fact that flame requires air for its sustenance, a fact which, although by no means generally admitted, found supporters from the time of Hero of Alexandria. One of the first air-pump experiments tried by Otto Von Guericke was for the purpose of ascertaining whether a candle would continue to burn in an exhausted receiver; and Boyle, in his first pneumatic treatise, (1660,) mentions several proofs that combustion cannot proceed in a space void of air. In an essay on this subject,* published by Boyle in 1672, we find hydrogen for the first time recognised as an inflammable body. Among other experiments, he poured upon iron filings "a saline spirit, which, by an uncommon way of preparation, was made exceeding sharp and piercing;" immediately "fumes" were given off, which proved to be inflammable. When allowed to burn within an air-pump receiver, the flame suddenly enlarged itself on exhausting, and then went out altogether. Boyle does not appear to have studied the properties of the new gas, but contents himself with suggesting that it consists either of "the volatile sulphur of Mars, or of metaline steams participating of a sulphurous nature."

* "On the Difficulty of Preserving Flame without Air."

Boyle also published in 1672 an essay entitled "*Fire and Flame Weighed in a Balance*," in which are detailed a number of experiments made to determine the amount gained by certain metals during calcination. We have previously* considered at some length John Rey's important treatise on this subject, published forty-two years earlier. One of the first papers read before the Royal Society (February 23, 1661) was "*On the Weight of Bodies Increased in the Fire.*" The experiments were made by Lord Brouncker at the Tower of London, and are given in detail in Sprat's "History of the Royal Society;" but they are by no means concordant—so little so, indeed, that it was not considered as a proved fact that metals gain weight at all during calcination; for we find on March 20, 1661, "The amanuensis was ordered to make the experiment of the calcination of antimony whether it increaseth or not, and to weigh it before and after, in and out of the water."

Boyle found that an ounce of copper filings, heated to redness for two hours, gained forty-nine grains, while an ounce of tin gained one drachm during calcination. Tin and lead heated in hermetically sealed vessels, underwent partial calcination, from which Boyle inferred that "glass is pervious to the ponderous parts of flame," and that the gain of weight during calcination arises from "extinguished flame" assimilated by the calx. Boyle reduced lead from its calx; hence he considers a calx neither the "caput mortuum" nor the "terra damnata" of the body calcined, as was generally believed, but rather as the body submitted to calcination *plus* something absorbed during calcination. It is curious that Boyle, who had worked upon the air with certainly more assiduity than any of his contemporaries, should not have attributed the increase of weight of calces to the action of the air upon the body calcined; more especially as in a treatise published in 1674 ("*Suspicions about Some Hidden Qualities of the Air*") he mentions that marcasite, when exposed to the air, becomes covered with a body of a vitriolic nature. He also considers that the efflorescence on walls comes from the air, and suggests there is a something of a solar or astral nature, possibly "a volatile nitre," dispersed throughout the air, and necessary for the sustenance of life and flame. As an additional reason for believing that there is some "hidden quality" in the air, he mentions that he made a liquid of "sublimate copper and spirit of salt," which was of a dirty, red color so long as it was kept in a closed phial, but when exposed to the air it changed to "a green exceedingly lovely."

I have mentioned above Boyle's supposition that there is "*a volatile nitre*" in the air, and this leads us to the consideration of that which I conceive forms the basis of pneumatic chemistry—the recognition of a connexion between the air and nitre. We shall find as we proceed the vast importance of the experiments which were made to determine the nature of that connexion.

Let us first understand how such dissimilar bodies came to be classed together. In the *Novum Organum*, Bacon urges the necessity

* *Chemical News*, vol. x., p. 208.

of collecting together what he calls "a number of instances agreeing in one form." "Inquisitio formarum," he writes,* "sic procedit; super naturam datam primo facienda est comparentia ad intellectum omnium instantiarum notarum, quæ in eadem natura conveniunt, per materias licet dissimillimas." Following out this last clause to the very letter, Bacon takes the heat of the sun as the first "instance agreeing in the form of heat," and classes with it the skins of animals and oil of vitriol, on the ground that the former (as he supposed) contained heat, and the latter burnt linen. On the same principle (and certainly with equal reason) some philosophers traced a relationship between the air and nitre:—nitre, when thrown upon red-hot coals, produces very intense ignition; a blast of air directed upon red-hot coals produces the same effect, the two instances obviously "in eadem natura conveniunt, per materias licet dissimillimas." This mode of procedure may appear crude and likely to mislead, when we consider Bacon's classification of instances agreeing in the form of heat, but it must be remembered that he gives negative instances which qualify the former, and enable the mind to decide whether certain instances, which appear at first sight to agree, may really be admitted as such. Moreover, the classification is only to be temporarily made, and then to be tested rigidly by experiment. The classification of the air with nitre (as also Newton's familiar classification of the diamond with combustible bodies) belong to that class of instances called by Bacon "instantiæ conformes sive proportionatæ," which he defines as "primi et infimi gradus ad unionem naturæ," leading the mind "ad axiomata sublimia et nobilia."†

Nitre has always been an important salt. It was known in the East from very early times, and after the invention of gunpowder was largely imported into Europe. Geber, the earliest writer on chemistry, (8th century,) mentions both nitre and nitric acid, and the former figures prominently in all alchemical and old chemical treatises. It was called *saltpetre* from the fact of its being found adhering to rocks (πετρος). Bacon attributes the force of gunpowder to the nitre which it contains, "which, having in it a notable, crude, and windy spirit, first, by the heat of the fire, suddenly dilateth itself, and we know simple air, being preternaturally attenuated by heat, will make itself room, and break and blow up that which resisteth it; and, secondly, when the nitre hath dilated itself, it bloweth abroad the flame, as an inward bellows."‡

Shortly after the establishment of the Royal Society, Mr. Henshaw (one of the first elected Fellows) read a paper before the Society "On the History of Nitre," § in which he says it is probable "that the air is everywhere full of a volatile kind of nitre" generated in the clouds, inasmuch as he has found it in dew and rain. He was informed, however, that no earth yields so much as that of a church-

* *Nov. Org.* Lib. 2, Aph. 11. † *Nov. Org.* Lib. 2, Aph. 27.

‡ "Sylva Sylvarum. A Natural History in Ten Centuries." Cent. 1, par. 30.

§ Read August 14, 1661, and printed in Sprat's "History of the Royal Society."

yard, a fact which militated somewhat against his theory. He speaks of nitre as "the darling of nature, the very basis and generation of nutriment." In a history of nitre written by one William Clark, and published in 1670, we find a section with the rather startling title "A Chemical Analysis of Nitre." Nitre was heated in a retort with potters' earth, when red vapors, smelling like aquafortis, and known as "the flying dragon," were copiously evolved—an analysis, indeed, in the broadest sense of the word, but scarcely justifying the title of the chapter describing it; for we must remember that a hundred years later the term "chemical analysis" could not justly be applied to any operation or series of operations in the chemistry of the period. Clark considers that thunder, lightning, and meteors are caused by nitre in the air; Sennertus attributed thunder and lightning to the meeting of nitrous and sulphurous vapors, an idea evidently originating from the knowledge of the composition and properties of gunpowder. Clark attributes the propulsive force of gunpowder to the sudden conversion of the nitre it contains into air. He mentions the fact that nitre was used by chemists for converting some metals into calx, and he considers that metals become rusted when exposed to the air on account of the nitre which it contains. The latter part of Clark's history of nitre is devoted to the statement of some remarkably wild and useless speculations. In one chapter the author proposes, and endeavors to support the supposition, "That the fiery rain of brimstone and fire on Sodom and Gomorrah was lightning, and that nitre is expressed by the word fire."

Boyle, in a short essay, entitled "*A Fundamental Experiment with Nitre*," mentions that he prepared pure nitre by crystallization, melted it in a crucible, and threw red-hot cinders into the molten mass until deflagration ceased. He then added "spirit of saltpetre" to the residue, and set aside to crystallize. The crystals were found to resemble saltpetre in every respect. He also prepared nitre by mixing "common potashes and aquafortis" and crystallizing.

Although a certain relationship between the air and nitre was very generally admitted, philosophers were by no means agreed as to the form and character of that relationship. Some maintained that the effects produced by the air are due to its containing nitre, others that the effects produced by nitre are due to its containing air. Thus, Hobbes and others considered that nitre consists of "many orbs of salt filled with air;" Gassendus, in common with a large number of philosophers, maintained that particles of nitre are diffused throughout the atmosphere; while Hooke, in his ingenious and philosophical theory of combustion,* affirms that the portion of the air which renders it the solvent of combustible bodies, "is like, if not the very same, with that which is fixed in saltpetre."

It has always been a matter of regret to us that Hooke's theory of combustion has received so little attention at the hands of the scientific. It was only last year that M. Chevreul (an authority on matters relating to the air) wrote in the *Comptes Rendus*, "On doit a Stahl

* See the tenth of these papers, *Chemical News* for February 17, 1865.

la Premiere Explication de la Combustion."* The theory of Stahl, unsupported either by experiment or sound reasoning, cannot be compared with the theory of Hooke, based upon experimental results, and supported by just and accurate reasoning. Hooke clearly showed the part which air plays in combustion; Stahl adopted the phantasy phlogiston. Then, as to priority, Hooke's theory was perfected when Stahl was in his cradle, and was published when he was four years old. Hooke's theory was neglected simply because it was so little known, and this was owing to the manner in which it was given to the world. Not published separately, it was not even designated a new theory of combustion. It forms part of an article on "charcoal or burnt vegetables" in the *Micrographia*, a work in which we should scarcely look for a new theory of combustion, inasmuch as it professes to detail "some physiological descriptions of minute bodies made with magnifying glasses." Moreover, there is nothing to guide the reader to the subject, and without reading the whole book he would not be likely to meet with it, for it is buried in a mass of irrelevant matter. It is, I conceive, in the causes given above that we must seek for an explanation of the fact that one of the most original and complete theories which has ever appeared in the history of science, was all but unknown in its own period, and has remained almost unnoticed down to the present day.

We have next to consider the important treatise "De Sal-nitro et Spiritu Nitro-aëreo" of John Mayow, the first of the five great works on pneumatic chemistry which were published before the discovery of oxygen.

* "Note historique sur les manieres diverses dont l'air a été envisagé dans ses relations avec la composition des corps."—*Comptes Rendus* for December 12, 1864.

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*On the Origin of Carbides and Combustible Minerals.**

By M. Berthelot.

From the London Chemical News, No. 341.

There is, in most instances, no difference of opinion as to the origin of combustible minerals—that is, when they are evidently derived from transformed organic matters. But is this the case under all circumstances? The carbides, petroleums, and bitumens, disengaged from the crust of the earth, often in great abundance, incessantly and from depths apparently lower than the stratified earth, do they always and necessarily result from the decomposition of a pre-existing organic substance? Is this the same with the carbides so frequently observed during eruptions and in volcanic emanations, and to which M. Ch. Sainte Claire-Deville has latterly called attention? Finally, should the same origin be assigned to the carbonaceous matters and carbides of hydrogen contained in certain meteorites, which seem to have an origin foreign to our planet? These are questions about which several distinguished geologists are still undecided. Without pretend-

* *Comptes Rendus*, vol. lxii., p. 949.

ing to decide so difficult a point, it seems to me interesting to find how the natural carbides of hydrogen may be formed synthetically—that is to say, by purely mineral reactions of the same kind as geologists have observed to take place between the substances contained in the interior of the globe, and those constituting its crust.

We will admit, according to M. Daubrèe's recent hypothesis, that the interior of the earth contains free alkaline metals. This single hypothesis, added to the experiments I recently published, almost necessarily leads to the explanation of the formation of carbides of hydrogen.

In fact, carbonic acid, everywhere infiltrated through the terrestrial crust, must come in contact with alkaline metals at a high temperature, and form acetylides in the same manner as in my experiments. These same acetylides may also result from the contact of earthy carbonates with alkaline metals even below dull red heat.

Now, these alkaline acetylides once formed will undergo the action of aqueous vapor. Free acetylene would hence result were the products immediately submitted to the action of the heat, and of hydrogen* and other bodies which might be present. But by reason of these diverse conditions acetylene will not be produced, as my recent experiments show. In its place are obtained, either the products of its condensation, which resemble bitumens and tars, or the products of the reaction of hydrogen on these already condensed bodies—that is to say, carbides more hydrogenated. There is scope for almost unlimited diversity in these reactions, according to the temperature of the bodies present.

The formation, in a purely mineral way, of all natural carbides may easily be conceived, and the formation would, moreover, be continuous, as the reactions causing it renew themselves incessantly.

The generation of carbonaceous matters, and of the carbides contained in meteorites, may be explained in the same way, provided it be admitted that these meteorites originally belonged to the planetary masses.

These hypotheses might be further developed, but I prefer to keep within the limits authorized by my experiments, and merely state geological possibilities.

* Produced at the same moment by the reaction of the water on the metals.

Cold Bleaching Process.

From the London Journal of the Society of Arts, No. 716.

M. Tessié du Mothay and M. Rousseau describe very satisfactory trials which they have made of a cold bleaching process, by means of which all textile materials, whether silk, cotton, linen, flax, wool, or any woolly fibre can be bleached. The agent employed is a permanganate of soda, slightly acid, prepared by a new and economical process. With this salt, the extraordinary properties of which have of late years been much studied, a bath is prepared, in which the materials to be

bleached are dipped. They are stirred about with a glass rod from time to time, and after about ten minutes they are taken out of the bath, strongly colored of a violet brown hue by an abundant deposit of oxide of manganese. They are then dipped as quickly as possible in a bath of water, acidulated with sulphurous acid, and again stirred and turned over with a glass rod, and after two or three minutes the materials or thread, originally of yellow or gray color, are already white. These operations are repeated twice more, and the result is a brilliant white, whilst the fibres are in no way injured. The materials operated upon were cotton fabrics, dirty as they came direct from the loom, as well as skeins of linen thread of a dark slate-color, which, by existing processes, would have taken many days to bleach.

Simple and Economic Process for obtaining Soda from Common Salt.

From the London Chemical News, No. 347.

Mr. Walter Weldon has taken out patents for a process described as follows: The new process consists in placing within a vessel capable of resisting the required pressure, an equivalent of common salt, and another of carbonate of magnesia, with a small quantity of water, and then pumping into the vessel the carbonic acid formed by causing atmospheric air to traverse coal in a state of ignition. The carbonate thus becomes bicarbonate of magnesia, which dissolves in the water, and then decomposes the chloride of sodium, chloride of magnesium, which remains in solution, and bicarbonate of soda, which precipitates, being formed. The whole process lasts but a quarter of an hour at most, and the cost is only that of the coal used in forming the carbonic acid. A moderate heat drives off the second atom of carbonic acid from the bicarbonate of soda, changing it into carbonate, and the magnesia may be recovered from the chloride by evaporating the solution containing it to dryness, and raising the residue to a temperature below redness.

On the Combustion of Gas for Economic Purposes. By Dr. Letheby.

From the London Chemical News, No. 344.

(Continued from page 249.)

The temperature of different combustibles is shown on the diagram below, and you will notice that the highest temperature produced by the various constituents of coal gas is that of acetylene, or the vapor of benzole when burned in oxygen, the heat of which exceeds 17,000° Fahr. The lowest temperature of all the constituents is about 12,700° Fahr., the temperature of burning carbonic oxide.

On the same diagram I have tabulated the thermotic power of a great number of substances. It is expressed in the number of pounds of water raised 1° Fahr. by a pound of the substance, and when the body is capable of being converted into gas or vapor, I have also expressed it in the cubic foot at common temperature and pressures.

Hydrogen, you perceive, is the most powerful thermotic agent, and carbonic oxide is the weakest. A pound of the first of these gases will raise 62,030 lbs. of water 1°, whereas a pound of the latter will only heat about 4325 lbs. of water to that extent. Examined by the cubic foot, and considering that for every pound of water raised 1°, about 48 cubic feet of air are raised to the same extent, we may say the chief constituents of coal gas have this thermotic power—

Pounds of Water and Cubic Feet of Air raised 1° Fahr. by a Cubic Foot of the Gas burning in Air.

Cubic foot of—		Lbs. water raised 1° Fahr.	Cub. ft. air raised 1° Fahr.
Hydrogen	heats.	329	15,837
Marsh gas	"	996	47,946
Olefiant gas	"	1585	76,299
Propylene	"	2376	114,378
Butylene	"	3168	152,502
Acetylene	"	1251	60,220
Benzole vapor	"	3860	185,814
Carbonic oxide gas	"	320	15,403
Common coal gas	"	650	31,290
Cannel coal gas	"	760	36,585

From this we can determine the practical thermotic power of any of these agents. A cubic foot of common gas will heat 65 gallons of water 1°, or 6·5 gallons 10°, or 3·25 gallons 20°; so that a bath containing 250 gallons of water would require about 77 cubic feet of common gas, or 66 of cannel, to raise its temperature from 55° to 75°. In practice, however, this is rarely attained, because of the faulty construction of the heating apparatus. I find, indeed, that a bath in my own house, made by Phillips, of Skinner Street, takes nearly twice this proportion of gas to heat it, and being in a closed room the atmosphere is almost poisoned before the bath is ready; and the circulation of the hot water is so imperfect that the top layer becomes boiling hot before the bottom of the water is warm. This is a subject which requires attention, for it is open to much improvement.

Again, with regard to the boiling power of gas, although in good practice a cubic foot of gas should boil off about 4712 grains of water, or about 22 times its own weight, yet this is not often attained, for in an open vessel we rarely evaporate more than 2866 grains of water, or about 13 times its weight.

But the heat of the burning gas is more surely applied to the warming of rooms; for, as you will see by the table, a cubic foot of common gas will heat an apartment containing 3129 cubic feet of air 10°, and the same quantity of cannel gas will heat 3658 cubic feet to the same extent. Other illuminating agents will, however, light for light, heat the atmosphere, and vitiate it to a larger extent. This is seen in the table which I brought under your notice at the last lecture.

TABLE *of the Combustion, Temperature, and Explosive power of Gases.*

	Per lb. substance.			Pounds of water heated 1° Fahr.			Temperature of combustion.				Explosive power.		Mechanical power per lb.
							Open flame.		Closed vessel.				
	Ox. used.	CO_2 produced.	Air vitiated.	Per lb. substance.	Per cub. ft. substance.	Per lb. ox. used.	With ox.	With air.	With ox.	With air.	With ox.	With air.	Tons raised 1 ft. high.
	Cub. ft.	Cub. ft.	Cub. ft.	Lbs.	Lbs.	Lbs.	Deg.	Deg.	Deg.	Deg.	At.	At.	Tons.
Hydrogen	93·4	0·0	467	62030	329	7754	14510	5744	19035	7852	25·6	12·5	21390
Marsh gas	47·2	23·6	826	23513	996	5878	14130	4762	18351	6680	37·0	14·0	8108
Olefiant gas	40·5	27·0	878	21344	1585	6225	16535	5217	21344	7200	42·9	15·1	7360
Propylene	40·5	27·0	878	21327	2376	6220	16522	5239	21327	7177	67·3	22·5	7360
Butylene	40·5	27·0	878	21327	3168	6220	16522	5232	21327	7177	85·8	30·2	7360
Acetylene	36·3	29·1	909	18197	1251	5914	17146	5142	22006	7009	37·9	17·6	6275
Benzole	36·3	29·1	909	18197	3860	5915	17146	5142	22006	7009	113·7	52·8	6275
Carbonic oxide	6·7	13·5	371	4325	320	7569	12719	5358	16173	7225	21·8	11·7	1490
Bisulph. carbon	14·9	5·0	689	6120	1239	4845	15280	4314	20031	5917	30·2	11·6	2110
Sulph. hydrogen	16·7	0·0	630	7444	671	5271	13688	4388	17542	6026	28·3	12·7	2567
Cyanogen	14·5	14·5	435	6712	925	5142	13188	5028	17645	6167	35·6	17·8	2314
Common coal gas	37·5	17·6	618	21060	650	6816	14320	5228	18101	7001	29·2	14·6	7262
Cannel gas	31·0	22·0	698	20149	760	6503	14826	5121	19046	7186	38·8	18·0	6945
Wood spirit	25·3	11·8	422	9517	819	6363	11435	4541	14902	6347	40·3	15·3	3290
Alcohol	24·6	16·4	533	12929	1597	6195	13305	4831	17223	6629	46·4	16·2	4455
Ether	30·9	20·4	664	16249	3217	6158	14874	5150	19225	6953	58·6	19·0	5603
Camphene	38·9	27·8	880	19573	7134	5942	16271	5026	20953	6922	47·6	16·0	6750
Spermaceti	37·0	25·2	815	17589	. .	6088	14599	4413	. .	. .	. .	. .	6065
Wax	37·7	25·6	829	15809	. .	4995	12921	4122	. .	. .	. .	. .	5451
Stearic acid	34·6	24·0	783	17050	. .	6061	15885	4818	. .	. .	. .	. .	5880
Stearine	31·4	14·2	527	18001	. .	6143	15815	5095	. .	. .	. .	. .	6207
Paraffin	40·5	27·0	878	21327	. .	6220	16522	5239	. .	. .	. .	. .	7354
Paraffin oil	40·5	27·0	878	21327	. .	6220	16522	5239	. .	. .	. .	. .	7354
Rape oil	38·7	24·3	801	17752	. .	6123	15830	5087	. .	. .	. .	. .	6121
Sperm oil	38·7	24·3	801	17230	. .	6088	15363	4937	. .	. .	. .	. .	5941
Carbon	31·0	31·5	913	14544	. .	5447	18329	3026	. .	. .	. .	. .	5015

Heating and Vitiating Effects of Different Illuminating Agents when burning so as to give the Light of 12 Sperm Candles.

	Lbs. water raised 1° Fahr.	Oxygen consumed, cu. ft.	Carb. acid produced, cu. ft.	Air vitiated, cu. ft.
Cannel gas............	1920	3 30	2·01	50·2
Common gas............	2786	5·45	3·21	80 2
Sperm oil............	2335	4·75	3·33	83·3
Benzole............	2326	4·46	3·54	88·5
Paraffin............	3619	6·81	4·50	112·5
Camphene............	3251	6·65	4·77	119·2
Sperm candles............	3517	7·57	5·77	131·7
Wax............	3831	8·41	5·90	149·5
Stearic............	3747	8·82	6·25	156·2
Tallow............	5054	12·00	8·73	218·3

The vitiating effect is calculated on the actual loss of oxygen, and on the power which 4 per cent. of carbonic acid has on the vital qualities of the atmosphere; and, though the results indicate that there should be less discomfort in a room lighted with coal gas than with any other illuminating agent, yet common experience is altogether in the opposite direction. The explanation of this is to be found not only in the fact that gas is used more lavishly than other agents, but also that in burning it produces a larger proportion of aqueous vapor, which, becoming diffused into the surrounding atmosphere, occasions great discomfort. Professor Tyndall has shown that the molecules of aqueous vapor are endowed with a remarkable power of absorbing the radiant heat of burning gas, and by thus becoming warm they create a sense of oppression. And again, when the warm atmosphere of a room is overcharged with moisture, it checks the action of vaporous or insensible perspiration, and this also causes distress. In all cases, therefore, where gas is largely used in rooms, provision should be made for the quick removal of the products of combustion.

When the heat of gas is required for warming a room, its radiant power should be increased by allowing it to ignite some solid substance, for the radiant heat of a non-luminous flame is very insignificant. I have here a Bunsen's burner, which gives with this gas the highest temperature of combustion, but the amount of heat which radiates from it is very small—smaller, indeed, than is the case when the gas is burnt in the ordinary way, when every atom of ignited carbon becomes a centre of radiation. The proportion of radiant heat from the same flame under different circumstances is very variable. From Bunsen's burner it is only 12, from the same gas burnt as a luminous flame it is 30, and with a spiral platinum in it it is 85. The introduction of solid matter into a non-luminous flame of high temperature changes its character altogether, and from the heat of convection it becomes heat of radiation. No doubt the quality of the vibrations is greatly changed, and they pass from the large and compara-

tively slow undulations of obscure heat to the small and quick vibrations of light; and the more this is affected, the greater and greater becomes the intensity of the radiant heat. Prof. Tyndall found that the following were the quantities of radiant heat from a platinum spiral, at different degrees of luminosity:

	Degress of heat radiated.
Platinum spiral, feebly red	19
" " dull red	25
" " full red	62
" " orange red	88
" " yellow red	158
" " yellow white	200
" " blue white	276
" " intense white	440

So that, when we wish to economize the radiant heat of burning gas, it is best to use it with some solid body, as fragments of pumice or pieces of asbestos.

The last point to which I would refer is the available or convertible motive power of burning gas.

The calculations of Dr. Mayer of Heilbron, and the experimental inquiries of Mr. Joule of Manchester, show that the mechanical power of heat is 772 lbs. raised a foot high for the heat necessary to raise the temperature of a pound of water 1° Fahr. A cubic foot of hydrogen in burning has, therefore, the mechanical power of ($329 \times 772 =$) 253,988 lbs.; and the same quantity of common gas has the power of ($650 \times 772 =$) 501,800 lbs.; while the power of a cubic foot of cannel gas is ($760 \times 772 =$) 586,720 lbs., raised a foot high. But if the same quantity of these gases is exploded with air or oxygen in a closed chamber, the mechanical power is somewhat different. I have here tabulated the expansive force of such a mode of combustion, and I may say that the calculations are deduced from the temperatures of combustion and from the volumes of the products, allowance having been made for the specific heats of the several products. It would seem, therefore, that the explosive powers of the several constituents of coal gas, when mixed with their proper proportions of air or oxygen, are as follows:

Explosive Power of Mixed Gases.

	Mixed with air. (Ats.)	Mixed with ox. (Ats.)
Hydrogen	12·5	25·6
Marsh gas	14·0	37·0
Olefiant gas	15·1	42·9
Propylene gas	22·5	67·3
Butylene gas	30·2	85·8
Carbonic oxide	11·7	21·8
Common gas	14·6	29·2
Cannel gas	18·0	38·8

These are the theoretical pressures exerted upon the sides of the containing vessel when these several gases are exploded with their proper proportions of air or oxygen; but as the explosion is never instantaneous, but proceeds from particle to particle, and therefore occupies time, and as the walls of a vessel always cool the products of the exploded gas to a great degree, this theoretical value is never obtained in practice, the highest pressure in the exploding chamber of a gas engine being only 75 lbs. on the square inch, or five atmospheres. The power of this has been determined experimentally by Mr. Evans, who informs me that, with a cubic foot of a mixture of 9 air and 1 gas, he has propelled a wooden shot (3 inches by 4) 50 yards; and he ascertained that the same effect was produced with an ounce of gunpowder. The motive power, therefore, of the exploding mixed gas is considerable.

In the gas engines of Lenoir it has been found that the best proportions of air and gas are eight volumes of air to one of common gas; theoretically the best proportion for London (13-candle) gas is 5·6 volumes of air to 1 gas. A larger portion of air is required for cannel gas, as 11 to 1; but in practice it is found that cannel gas does not produce so good an effect as common gas. The time of the explosion is about the twenty-seventh part of a second, and the temperature of it is about 2474° Fahr. instead of from 5228° to 7000°, the calculated temperatures for open and closed chambers.

The machines which are used for practically employing this power are all modifications of the original engine of Lenoir. They consist of a cylinder with a double-action piston, receiving the mixed gas alternately on either side of the piston. The arrangement is such that, in the movement of the piston, the air and gas, in proper proportions, (8 to 1,) are drawn into the cylinder by a suitable side valve, and when the piston has made half a stroke it shuts off the valve; at that moment the mixed gas is fired in the cylinder by means of an electric spark from a Ruhmkorff's coil passing between the points of two wires in the cylinder. One of these wires is insulated by traversing a rod of porcelain fixed in the cylinder, and, being in connexion with a make-and-break contrivance, called a distributor, attached to the fly-wheel of the engine, it receives the charge of electricity, and so fires the mixed gas at the right moment. The expansion caused by the explosion and heat of combustion drives the piston through the rest of the stroke, and it generally ends with a good deal of unutilzied pressure. In one case I find that the indicator recorded an initial pressure of 75 lbs. on the inch at the moment of explosion, and a final pressure of 25 lbs. The loss of power in this case must have been considerable, for not only is there the loss of the difference (12·5 lbs.) between the calculated pressure, 37·5 lbs., (75 ÷ 2,) and the real, (25,) but there is also the total loss of the unavailable final pressure. A part of this loss is no doubt due to leakage, and to the cooling effect of the walls of the cylinder; for the temperature has been observed to fall from 2474° Fahr., at the moment of explosion, to 1438° at the end of the stroke, the calculated temperature being 2156°. Indeed, the management of the temperature is one of the difficulties of the engine, for the

cylinder has to be cooled by a stream of water. Improvements will no doubt be made in the construction of the engines, and especially in the utilization of the residual power, and this must be done by shutting off the valve and firing the gas earlier in the stroke. This has already been done to some extent in America with engines of half horse power, as with cylinders of $4\frac{5}{8}$-inch diameter by $8\frac{3}{4}$-inch stroke; and this with 185 revolutions, or 370 explosions, in a minute, raises 16,280 lbs. 1 foot high in a minute. In France and in this country much larger engines are made, as from 1 to 3 horse power.

The quantity of gas used in the working of the engine is rather variable. In the American engine, already alluded to, it took 105 cubic feet of gas an hour to work an engine of half horse power, and a one horse engine in London takes about 185 cubic feet of London gas—say it is 200 cubic feet—per horse power. This is 1,980,000 lbs. a foot high; whereas the theoretical power of 200 feet is more than 100,000,000 of lbs.

The advantages of the engine are very great; for it takes up but little room, it is very clean, it works with great regularity, it requires little or no attention, and it costs nothing for fuel when it is not at work.

One thing I ought to mention in speaking of the explosive power of mixed gas, and that is the effect of using mixtures in improper proportions. Sir Humphrey Davy found, in his experiments with marsh gas, that there was but one proportion of air and gas which gave the maximum effect, and that was a mixture of 1 of gas and 7·5 of air, (theoretically it should be 1 to 9·5.) When the proportions are reduced in either direction the mixture becomes less and less explosive, until with 1 gas and 15 air, or with equal volumes of gas and air, the mixture ceases to explode.

In the case of coal gas, although the theoretical proportions for London gas are 1 of common gas* to 5·6 of air, and 1 of cannel gas to 7·4 of air, yet the best results are obtained with 1 of the former to 8 of air, and 1 of the latter to 11. On either side of this proportion the mixture rapidly becomes less and less explosive.

The effect of mixing other gases with explosive mixtures has been well studied by Davy and others. Taking, for example, an explosive mixture of 2 volumes of hydrogen and 1 of oxygen, it is found that 1

* *Average composition of London gas by volume.*

	Common gas.	Cannel gas.
Hydrogen	46·0	27·7
Light carburetted hydrogen	39·5	50·0
Olefiant, &c	3·8	13·0
Carbonic oxide	7·5	6·8
Carbonic acid	0·7	0·1
Aqueous vapor	2·0	2·0
Nitrogen	0·5	0·4
	100·0	100·0

of nitrogen to 6 of the gas, or 1 of carbonic acid to 7 of it, will stop its explosion.

Lastly, the temperature at which these gases are fixed is a matter of considerable importance. Davy found that he could not set fire to marsh gas, (the fire-damp,) or to an explosive mixture of it with air, by using the strongest heat of glowing charcoal. He even blew a mixture of the gas upon glowing charcoal until he got it at a maximum heat, without firing it; nor can it be fired by the sparks from flint and steel. Not so, however, with hydrogen, or olefiant gas, or carbonic oxide, all of which are fired by the sparks and by glowing charcoal—perhaps the igniting temperature is about 3900° Fahr., and the vapor of bisulphide of carbon is fired at as low a temperature as 300° Fahr. These facts are deserving of attention; for they show that gas leaking from the mains may be fired by a spark from a pick, or from the chipping of a hole in the pipe in laying a service.

And now, gentlemen, we have gone over the question of the phenomena of gaseous combustion, and of the manner in which gas is to be most profitably and most economically used for illuminating purposes. We have also examined the thermotic powers of coal gas, and I hope if I have the opportunity of meeting you again, I shall be able to bring under your notice one other question of interest to gas engineers, and that is the profitable utilization of the waste products of gas-works.

MISCELLANIES.

Effect of Forests on the Temperature of the Air.—The MM. Becquerel, in an elaborate memoir upon this subject, presented to the Academy of France, reach the conclusion that the temperature is higher away from the forest than within it, and higher within than immediately around it. The mean temperature of the trees appear to be that of the surrounding air; but changes take place much less rapidly in the trees, especially in the trunks. The phenomena of vegetation do not appear to influence the temperature, for the temperature of the leaves scarcely differs at any time from that of the air. A singular observation is that forests have the property of preserving tracts lying to leeward of them from hail. The windward edge of the forest is frequently attacked, but the hail becomes less and less as it penetrates the forest, soon ceases, and is not reproduced for some distance from the leeward edge.

Capillary Attractions.—This subject has attracted the particular attention of the distinguished chemist M. Chevreul, whose position as director of the government establishment for the manufacture of Gobelin tapestry has already led him to a number of very important investigations, especially those in reference to the harmony and contrast of colors. The phenomena of dyeing appear to have led him to his present researches, which were conducted in reference to the absorption

of linseed oil and water by powdered kaolin, common clay, and white lead. His conclusions are, that there is in capillarity an elective attraction, and that the linseed oil has a higher *capillary affinity* for white lead than water has, but that water has the higher *capillary affinity* for kaolin and clay. He proceeds to apply these facts to the explanation of a number of phenomena in nature and in the arts.

Testing of Ships' Compasses.—A M. Gilbert Govi suggests, through the pages of the *Cosmos*, a very simple means of ascertaining whether a ship's compass has had its poles reversed by a stroke of lightning. It consists simply in making a galvanic couple by plunging a small plate of zinc and one of copper into sea-water, and connecting them by means of a copper wire. This wire being held close above the needle will deflect it. Ampere's rule for remembering the direction of the needle is as follows: Suppose the observer to be lying on the connecting wire looking towards the needle, the end connected with the copper plate being at his feet, the zinc end at his head. The north end of the needle is thrown towards the left. This will in any case determine the position of the poles of the needle, or if the wire be wrapped in a helix around a bar of soft iron, this wire becomes magnetic, the poles being so adjusted that, if looking from the copper towards the zinc end the wire winds direct, (that is in the direction in which the hands of a watch move, or from left over to right,) the end towards you is the south end. By placing the needle in a coil of this kind, if its magnetism has been destroyed by the flash it may be restored in a few minutes.

M. Govi further recommends, if the means of constructing the galvanic couple be not at hand, to take a bar of soft iron, heat it white hot so as to destroy all magnetism which it may possess, and after it has cooled hold it in a vertical position, near the two ends of the needle successively. A bar of soft iron held vertically becomes temporarily magnetic; in the north magnetic hemisphere, its lower end becomes a south pole, in the south magnetic hemisphere a north pole. This latter expedient will answer very well, provided the ship is not too near the magnetic equator, which is, unfortunately, precisely the region where the accident is most apt to occur.

Duration of the Impression of Light on the Eye.—Abbé Laborde describes a curious experiment which seems to show that the more refrangible rays of the spectrum make a more durable impression on the retina than those less refrangible. A beam of sunlight is admitted into a dark chamber through a narrow slit, (6 millimetres by 3 millimetres.) In its path is adjusted a rotating disk of metal having slits cut in its circumference so that the beam may be passed and stopped alternately as the disk turns. The observer is placed behind a ground glass screen upon which the beam when passed is received. A brake on the axis of rotation allows him to adjust the velocity of the disk. At low velocities the appearances of the beam follow each other slowly, and can be distinguished. The light being white, as the velocity increases, the

image becomes tinged with color in the following order: Blue, green, rose, white, green, blue. After the second blue, the image appears white at all velocities. The experiment is curious and would seem easy to repeat.

Water of the Dead Sea.—This curious inland water, equally interesting on account of its history and its physical peculiarities, has been recently thoroughly explored by the Duc de Luynes. Contrary to the general belief, he found in the southern portions of it, around the ruins of Sodom, fishes who appeared to be living and multiplying their species comfortably. M. A. Terreil, who accompanied him, procured a number of specimens of the water from various localities and at different depths, and M. Daubree has analyzed them and communicated his results to the Academy of Sciences of Paris. The following are his general conclusions:

1. The density of the water of the Dead Sea increases with the depth.

2. The composition of the water is not identical throughout its extent, even when those localities near the mouth of the river and the small streams which enter it are excepted. Thus, the water taken five miles to the east of Ouadi Mrabba contains four times more lime than that taken five miles east of the Ras Feschkah; but the latter contains twice as much sodium as the former.

3. The concentration of the water is also very variable in different localities.

4. The water collected to the north of Sodom, in the part which forms a lagoon, contains more chloride of sodium than chloride of magnesium, which is the reverse of the ordinary character of the waters of the Dead Sea, and explains the possibility of fishes living there.

5. The proportion of the saline matters remains the same at all depths; except that the bromides appear to concentrate at depths of 300 metres.

6. The water of the Dead Sea appears to contain no iodine nor phosphoric acid.

7. The spectroscope detects in the dried salts neither lithium, cœsium, nor rubidium. It contains but little sulphuric acid, but is composed almost exclusively of chloride of magnesium, sodium, calcium, and potassium, and of a certain quantity of the bromides of these bases.

Their relative richness in bromine and potassa is such as to deserve the attention of manufacturers of these articles.

8. The waters of the rivers and springs around the Dead Sea are composed of chlorides, sulphates, and carbonates of lime, magnesia, soda, and potassa, and contain no bromine appreciable to analysis.

Photo-lithography.—M. Pinel Peschardiere has communicated a new process for transferring photographs to stone, to the French Photographic Society. The process is not very distinctly described in the *Cosmos*, whence we take the notice, but seems simple and effective within the limits in which Mr. Osborne has already succeeded so well,

that is, in the production of engravings. Are we ever to have his process accessible and on a practical scale?

Cheap Meat.—The peculiar climatic and financial conditions of our country are, unfortunately, such that, notwithstanding the heroically virtuous efforts of our farmers or butchers, (exactly which, does not clearly appear; in fact, appears differently, according to the part of the market in which the question is asked,) the price of meat is continually rising, and it is evident that before very long our working classes will be brought to the condition of those in Europe, and be compelled to live without meat. In such a state of things we look with interest upon all methods of furnishing cheap meat to our markets, and call attention to a communication made to the Academy of Sciences, of Paris, by M. Vavasseur, detailing a method recently introduced in Uraguay, where heretofore myriads of cattle have been slaughtered yearly for their hides alone.

The animal is knocked in the head, bled with the greatest care, (an indispensable condition for the preservation of meat in hot climates,) skinned rapidly without blowing, and quartered. The meat, still palpitating, is cut up rapidly into slices from 5 to 6 centimeters (2 to 2½ inches) thick, and as large as possible. One of these is laid upon a bed of fine salt on a pine board, covered with a layer of the same salt; then another piece is laid upon it, and thus a pile is made as high as is convenient, which is left for about twenty-four hours, and then repiled in the inverse order with fresh salt, so that the lower pieces become the upper, and *vice versa*. After standing from twelve to fifteen hours more, the pile is again taken to pieces and the meat heaped up in a corner of the slaughter house in the open air, and merely covered with a piece of tarpaulin to protect it from the rain, sun, and dust. It remains here until sold. It is then subjected to the heaviest possible pressure, which, besides diminishing its volume, contributes efficaciously to its preservation, and is delivered in packages of 60 centimeters long, (24 inches,) 30 in breadth and height, weighing 100 Spanish pounds, (46·638 kilos. or 102·5 pounds,) which are wrapped carefully in bale cloth. The manner of using this meat is very simple. It is soaked for a dozen hours in fresh water, which removes the excess of salt, softens it, and gives it nearly the appearance of fresh meat. Boiled, it gives an excellent soup, and the meat is certainly preferable to the pork and salt beef in use in the navy. Cooked in other ways, and especially with vegetables, it furnishes an excellent nourishment. It can be sold to the consumers at 60 centimes the kilogramme (representing, after soaking, 1·5 kilos.) at the port of delivery, or 75 centimes at Paris. This would make the price in our currency, at Paris, about 7½ cents per pound of the material as delivered, or 5 cents per pound of the soaked meat.

Bearing upon this subject we find the following in the London *Daily News*, of September 28, (extracted by the New York *Tribune*,) and are glad to see that the subject is attracting attention in England. We should like to have a more full explanation of the Sloper-McCall pro-

cess, and do not implicitly believe in the "certain gas," which can be injected and preserve meat fresh for an indefinite period; but in the preservation itself we do fully believe, and in its vast importance to our working people. Will not some of our enterprising men look into the subject, examine the various processes proposed, and give us the benefits of their investigations?

"A very interesting *reunion* was held yesterday at the London Tavern, the object of which was the important one of ascertaining whether our present very deficient supply of animal food might not be supplemented from the illimitable Pampas of South America. The object of the meeting was stated by Mr. Paris, who explained that, at a previous social meeting held in the London Tavern, in November last, the advantages of an invention for preserving meat fresh were tested, and were pronounced to be successful. The inventors were Messrs. McCall and Sloper, and the process was the introduction of a certain gas, the nature of which is still the secret of the patentee, by means of which the meat was preserved fresh for any possible period. Armed with this invention, and provided with parcels of English beef cured according to the Sloper-McCall process, Mr. Paris proceeded to Buenos Ayres, and at a public entertainment there convinced all the local authorities that beef could be preserved perfectly fresh over the voyage to England. The government of Buenos Ayres, seeing the advantage that might accrue, gave Mr. Paris every facility for procuring the beef of the country, and it was some of this beef cured according to Mr. McCall's process that was served up at yesterday's luncheon. Before its introduction, Mr. Paris stated very candidly that the experiment was made under unfavorable circumstances, the present year having been a very bad one for cattle in La Plata. The agent of Messrs. Sloper and McCall having fallen sick, and been obliged to communicate the curing process to him, (Mr. Paris,) and the local workmen having put the beef into pans of pine wood instead of that which had no flavor of turpentine. The meat, however, was prepared under the inspection of Messrs. Zimmerman, the principal merchants of Buenos Ayres, and it now came before the London public, genuine South America beef of the Pampas, and preserved solely by the process patented by Messrs. McCall and Sloper.

"After this exordium, the luncheon, which consisted exclusively of Buenos Ayres beef, was put on the table in the various forms of roast, stewed, and in pies and puddings. The company ate heartily of the beef in all its varieties, and were unanimous in their approval of its freshness and flavor, giving, however, due credit to Mr. Nicholls, the eminent *chef* of the London Tavern, who had taken care that it should be dished to the best advantage. The roast beef was very fine, quite as good as the *filet de bœuf* of the first-class Paris *tables d'hôte*, and the stewed beef and puddings were admirable. There could be no doubt but that, if imported extensively, the La Plata beef, prepared according to the McCall process, would be a most valuable addition to the food of London, especially, as we can state, on the authority of Mr. Paris, that it could be sold by retail over the counter at prices varying from four-

pence-halfpenny to sixpence per pound, according to the capacity of the retailer. At the conclusion of the luncheon, cases of the raw meat which had been imported from Buenos Ayres were opened in presence of the company, and appeared and smelled as fresh as if they had been packed yesterday. It was, in fact, really good, succulent meat, and was unhesitatingly pronounced to be such by Mr. Warrener, the well-known preserver of fresh meat for the army. The importance of this process, as well as the labors of Mr. Paris in procuring a supply of the raw material, can hardly be overrated when we recollect that 2,500,000 of black cattle have up to the present date been annually killed in La Plata solely for the sake of their hides, the meat being left to the vultures, while we, in this country, have been paying famine prices for meat of not very superior quality. At the close of the proceedings, a resolution affirming the success of the process was proposed by Mr. Ravolta, and assented to by general acclamation."—*London Daily News.*

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Explosive Paper.—We take from Dr. Phipson's correspondence in the *Cosmos* the following directions for the preparation of this material, which may have its uses in the arts, and which, some time ago, in one of its forms, attracted considerable attention among us:

Take chlorate of potassa	9 parts.
" Nitrate of potassa	$4\frac{1}{2}$ "
" Ferro-cyanide of potassium	$3\frac{1}{4}$ "
" Wood charcoal, pulverized	$3\frac{1}{4}$ "
" Starch	$\frac{1}{2}$ part.
" Chromate of potassa	$\frac{1}{16}$ "
" Water	79 parts.

Mix the solid ingredients in the water, and boil for an hour, stirring well. Pass the paper through the solution, and dry at the temperature of boiling water. If intended for cartridges the paper is to be rolled into the cylinders before drying. The experiments tried with this substance, in comparison with gun-cotton, are said to have been favorable to it. It explodes only in contact with flame, is quick and powerful in its action, and does not leave any greasy residuum in the gun. It produces less smoke than common powder, and is less sensitive to dampness. According to the author of the recipe, (Mr. G. S. Melland, of London,) it may be completely preserved from the damp by applying to it a varnish of xyloidine, made by dissolving one part of paper in three parts of nitric acid, of density 1·040. By substituting the chromates of strontia, or other coloring matters, the experimenter will probably be able to reproduce those beautiful colored flames which attracted so much attention some time ago.

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Natural Colors in Photographs.—M. Poitevin presents to the Academy of Sciences, of Paris, the following process for photographing in colors: "Photographic paper being previously covered with a coat of violet subchloride of silver, obtained by the reduction by light of the white chloride in presence of a reducing salt, I apply to its surface a liquid formed by a mixture of one volume of a saturated so-

lution of bichromate of potassa, one volume of a saturated solution of sulphate of copper, and one volume of a solution of 5 per cent. of chloride of potassium. I allow the paper to dry, and keep it out of the light; it will remain good for use for several days. The bichromate is the principal agent, and may be replaced by chromic acid, but not advantageously; the sulphate of copper assists the action, and the chloride of potassium preserves the whites which are formed. For paintings on glass the exposure to light is only from five to ten minutes, and is proportional to the greater or less transparency of the color. The color may be watched as it comes. The paper is not yet sufficiently sensitive to be used in the camera; but colored images may be obtained on it in the enlarging apparatus. To preserve these pictures in an album, it is sufficient to wash them in water acidulated with chromic acid; then treat them with water containing bichloride of mercury, wash them in water charged with nitrate of lead, and then with water. After this preparation, they do not alter out of the light, but grow brown in the direct light of the sun."

M. Becquerel remarked that the colors were not quite as bright as those procured upon silver plates, and that especially the blues and violets were less decided; they were not more rapidly produced, nor more stable, but as they were more easily got, he regarded M. Poitevin's process as one of great *interest.*

Work done in Rowing.—Prof. Haughton, of England, has applied the mechanical formulas to the determination of the work done by the crew of the Oxford prize-boat, eight in number, rowing their boat one mile in seven minutes, and finds the amount of work done to be 204·57 foot-tons, 28·07 foot-tons per man, or 4·01 per man per minute, and he remarks, "A good idea may be formed of the rate at which the muscles give out work in a boat race, from comparing this work with the average daily work of a laborer. At most kinds of labor there are 400 foot-tons of work accomplished in ten hours. In a boat race, the oarsman produces in one minute the hundredth part of his day's labor, and if he could continue to work at the same rate he could finish his day's task in one hour forty minutes, instead of the customary ten hours.

"The work done, therefore, in rowing one knot in seven minutes is, while it lasts, performed at a rate equal to *six times* that of a hard-worked laborer."

The memoranda of the editor of the *Journal* are also worth remembering. "We believe the foregoing to be one of the most probably accurate determinations of the few that have been made of the muscular force given out in rowing; and we agree with Professor Haughton in thinking that the comparison with the Oxford traction experiment is confimatory of his conclusions. In any case it fixes the limit of present presumable error at about 10 lbs. resistance, which, we apprehend, might disappear were the Oxford experiment repeated, and at a higher speed. The result, showing the great excess of labor for the unit

in time over and above that of an average day's work, is by no means startling, especially if reliance is to be placed upon the experiments of the late Mr. Robertson Buchanan, showing that in the following modes of applying muscular effort, rowing is the most advantageous of all others in the ratio of the annexed numbers:

Pumping	100
Turning winch	167
Bell ringing	227
Rowing	248

"The value of the investigation causes us the rather to desire that the actual resistance to traction of the Oxford race boat, loaded as with her crew, and *at her race speed*, should be experimentally ascertained.

"A good deal of valuable information, but very little known in England, on the subject of human force, and the relation between its absolute force or energy and the velocity with which it is given forth, and the time of its endurance, will be found in Bouguer, "Manœuvres des Vaisseaux," and in Euler's Memoirs in the Transactions of the Academy of St. Petersburg, new series, vol. ii. and vol. viii., in the last of which he examines the animal mechanics of rowing. Schultz's experiments, in the Memoirs of the Academy of Berlin, for 1783, also are probably the most complete that have ever been made upon human effort, and especially in reference to the relation (for a given form of muscular exertion) between height, weight, and absolute force in the man, and the result in work. This applies in a very direct way to the much debated question among oarsmen, as to what average size and weight of men in an eight-oar boat ought, *cæteris paribus*, to give the best results in speed. The Oxford view is, we believe, that heavy men (11 to 12 stone) give the best result, and this seems supported by the facts of their actual weights of crews and their general success. With heavy men especially, but, in fact, with men of all weights, there can be scarcely a doubt but that the proper proportioning the rate of stroke, so that the trunk of each man as it oscillates shall move as a pendulum pivoted on the hip-joints, and therefore with the least effort, and the right proportioning of the length of oars and all else, to give to the muscular effort expended *the fullest value at this rate*, has a by no means insensible effect upon the issue. A view which appears supported by the measured stroke of Oxford as against the quicker rate of Cambridge.

"Hachette, 'Traité des Machines,' and the late Mr. B. Bevin, C.E., have given also some important experimental results as to animal effort continued for long and short times, and Professor Leslie has placed on record some curious observations upon the subject. The sedan chairmen of the last century were accustomed to go along for perhaps half an hour, at the rate of 4 miles per hour, under a burden of 300 lbs., not always equally divided between them, and a case is recorded (how trustworthy we cannot say) of half a mile having been so done in five minutes and some seconds. For a short distance, say not more than 100 or 150 yards, the porters of Constantinople or the *fachines*

at Marseilles and other Mediterranean ports, do not refuse a burden of seven or eight hundred-weight carried on the back, with which, in a stooping posture, and sometimes aided by a staff in one hand, they travel at the rate of probably two miles per hour, if not faster."

Electric-light Regulator.—The Committee of the Society for the Encouragement of National Industry, of Paris, having examined a new regulator submitted to them by M. Gaiffe, report that it is much simpler than any one in use, and requires no escapement apparatus. The carbon-holders are perfectly balanced and slide easily by friction rollers. The approach of the carbon is effected by means of a barrel and two wheels of unequal diameters which gear into the racks attached to the holders, this system being operated by an electro-magnet attracting the iron rod which terminates the lower holder. The helix of the magnet is wrapped in a peculiar way, so that when the lower carbon-holder is at the lowest part of its course, and has the feeblest attraction from the magnet, the magnetic action developed is a maximum. A peculiar arrangement also allows the luminous point to be centered without any change in the distance of the carbons. After experimenting upon this apparatus the Committee report:

1. That this regulator operates as regularly as the most perfect one in use.
2. That it is automatic; that is, it can light itself without requiring any previous separation of the carbons.
3. That it operates in any position and produces a luminous point in a constant position.
4. That in consequence of its position its manipulation is easy.

These advantages being joined to the power of adjusting the position of the luminous point and the cheapness of the apparatus, the Committee think the apparatus worthy of approval.

A drawing, showing the apparatus in detail, will be found in the report of the Society for February, 1866.

Protection at Sea.—Another fearful disaster has for a moment excited the attention of the public, and shown travelers how insecure they are in entrusting themselves to the care of even well-reputed companies. The swamping at sea of the steamer *Evening Star* and consequent drowning of some two hundred passengers, of whom the larger part were women, must lead every one to inquire whether such accidents are unavoidable.

So far as we can judge, from the very reserved accounts which we have had of the accident, the steamer was caught in a violent cyclone, her rudder-chains jammed in the sheave of one of the pulleys, and she was thrown helpless into the trough of the sea, and either sprung a leak, or, as seems more possible, her hatch-coverings were swept away, and the sea, which was sweeping over her decks, poured into her cabins and hold, and carried her down. Of course, she was insufficiently supplied with boats, and they were useless, swamped in launching them,—

that appears to be the regular formula for a wreck at sea. But may we not inquire whether the officers of our passenger steamers, who are every week sailing with crowded cabins and steerage, are aware of the nature of the hurricane as it has been demonstrated by Espy, Redfield, Reed, and others, and of the rules for avoiding their severest shocks which have been given by Piddington, Blunt, and many others? The officers of our navy are familiar with them, as is evident by a report of this very storm made to the Navy Department by Lieutenant-Commander Gibson, U. S. steamer *Tohoma*, who seems to have saved his ship by attention to these rules. The captains of the British mail packets, who run to and through the West Indies, recognise and obey them, and thus shorten their voyage and diminish materially their expense and the danger of their passengers. Ought not the officers of our vessels, which run regularly along what is probably the most dangerous coast in the world, be required to be familiar with them and to observe them? The rules are simple, easily applied, and, so far as anything human can be, apparently infallible. Ought not, then, a commander of a passenger steamer to be dismissed for getting his ship into the heart of a hurricane? Again, is it impossible that a ship should be made unsinkable? If it be possible, no expense is too great for the security of the passenger. Now, it seems that, in this case at least, the steam syphon pumps, of which we hear much recently, would, in all probability, have saved the vessel. We know that they have been tried in our navy and successfully. Why should they not be required by law on board of all passenger ships? We published some years ago a plan proposed, if we remember right, by a Frenchman, which appears perfectly feasible and efficient against a leak. It consists in making all the rooms and compartments of the vessel approximately air-tight, when the doors are closed, and connecting them all with an air-pump, worked by the main or by the donkey engine. As the atmosphere corresponds to a column of water of more than 30 feet in height, it is very evident that a very small increase of the pressure in the room will drive the water out of the leak and allow access to it, so that it may either be stopped or the pressure maintained until the vessel reaches a port. But whatever may be said of individual propositions, there must certainly be means of increasing the safety of the passengers, and the government ought to seek them out and require their appliance. Why should not the National Academy of Sciences be engaged in examining this subject? Its charter by Congress apparently looked exactly to such employment. In the case of the *Evening Star* the shock of the disaster is increased by learning that she came very near meeting the same fate in the January trip, when the captain lost his life in his endeavors to save the vessel. On this occasion it seems that the passengers signed a statement warning passengers against the dangers they incurred owing to the manner in which the vessel was sent to sea, which statement was sent to the New York papers for publication, but refused by them; and even since the warning has been justified by the event, but one of the New York papers (the *Times*) has published this paper or made any allusion to it, so

entirely useless is our daily press as a safeguard against companies which advertise in their columns.

Since writing the above, we find the following in the New York *Tribune:*

"The Evening Star Disaster.—On Friday last the official investigation into the circumstances attending the loss of the *Evening Star* was concluded, and the report was forwarded to Washington. From the report it appears that the wreck was caused by an insufficiency of crew. Her entire crew numbered only ten men, four of whom were detailed as quartermasters, leaving the effective force only six. The evidence shows that she laid in the trough of the sea from 10 o'clock at night until 6 the next morning, and that no effort was made to get her head to the wind, though her rudder was intact for the most of this time, and jury masts could have been rigged. The water was often breast high on her decks, and passed into the hold through the hatchways and other apertures on the decks and sides. There was no carpenter on board to repair damages. The hull of the ship was staunch and tight; the engines were in perfect order; and, properly manned, the vessel could have lived through the cyclone, and carried her passengers into a port of safety."

Let us see now whether a rich company can commit manslaughter under the laws of this country.

New Galvanic Couple.—M. Mialaret-Becknell, of Louisiana, sends to the Academy of Sciences, of Paris, an account of a new galvanic battery invented by him. In a glass vessel, filled with a solution of hyposulphite of soda, is plunged a cylinder of copper. Within this cylinder is placed a porous cell, containing a solution of sulphate of copper in which is placed a sheet of copper bent in the form of an S. When the poles are connected, the cylinder of copper is gradually converted into sulphuret of copper, and the sheet in the porous cell is coated with galvanic copper. The residues furnished by the pile are sulphate of soda of no commercial value and sulphuret of copper, which, by simple roasting, is converted into sulphate and serves to feed the pile. He states that he used a battery of this kind with good effect during the rebellion, when it was impossible to obtain zinc.

Sodium Amalgamation.—The discovery of this process, which promises to prove a very valuable one, is claimed in this country by Mr. Wurtz, in England by Mr. Crookes. Mr. Wurtz's patent is considerably prior in date, and there is every reason for believing that his results were known in England before the date of Mr. Crookes' patent. It might also be considered a little awkward for Mr. C., that he had a similar dispute on the subject of the discovery of thallium, in which the French discoverer had considerably the best of the argument. All this would not have been worthy of notice, for it is not the first nor the hundredth time that English inventors have played this trick; but in an eulogistic notice of the process in the *Journal of the Society of Arts*, which takes no notice of Mr. Wurtz's claim, the editor cites the experiments of Prof. Silliman, which were made on Wurtz's invention. This is rather too hard to be borne.

New Process in Photography without the Aid of Light.—Mr. Hodgson, photographer, Sheffield, writes: "Last October the *Illustrated London News* issued a picture, along with the paper, of the 'Kingfisher's Haunt.' Having no use for it I put the picture in a drawer, between two sheets of paper prepared for enlarged photographs. The paper is prepared with 400 grains of isinglass, 440 grains of iodide of potassium, 146 grains of bromide of potassium, and 54 grains of chloride of sodium, to 40 ounces of water. This paper is quite insensitive to light; but what was my astonishment, on looking in the drawer last Tuesday, to find the paper on the top of the picture a negative, the sheet underneath a fine positive, the light greens and blues becoming white, and the reds becoming red, in the positive. Those pictures I hung in the light for two days, and they faded away. One sheet I have put under again, and several quires of blotting-paper on the top, and another positive is printing on the same paper, which I hope to be able to fix."—*Prac. Mec. Jour.*, August, 1865.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, October 19, 1866.

In the absence of the President and Vice-Presidents, Mr. Coleman Sellers was called upon, by motion, to take the chair, and the meeting being called to order, the minutes of the last meeting were read and approved.

The Board of Managers reported their minutes, and the following donations to the Library: From the Royal Society, the Royal Geographical Society, the Zoological Society, the Society of Arts, and the Institute of Civil Engineers, London, England; the Osterreichischen Ingenieur-Veriens, Vienna, Austria; the Canadian Government, Ottawa, Canada; Frederick Emmerick, Esq., Washington, D.C.; Benjamin Bannan, Esq., Pottsville, Pa.; and Thomas S. Fornon, Esq., Philadelphia.

The various Standing Committees reported their minutes, and the Special Committees reported progress.

The regular monthly report of the Resident Secretary on novelties in science and the mechanic arts was then read, as follows:

Secretary's Report.

ENGINEERING WORKS, &c.—Water supply of London.—We read, in the journal entitled *Engineering*, that surveys are in progress, with a view of diverting from the Severn the sewage of all the towns lying on that stream above Tewkesbury, and making arrangements for obtaining water from that place, carrying it to reservoirs, from which it might flow into London under high pressure.

The estimated cost of these works, made by Mr. Hamilton Fulton, is £3,000,000, ($15,000,000.)

From the same paper we learn that the five water companies now drawing their supply from the Thames offered to pay £1000 each, per year, if the sewage were diverted from all points of the river above

their sources of supply. This offer was made on occasion of the Thames Navigation Bill being brought before Parliament, and, though the plan was opposed by the Thames Commissioners, the amended bill was carried, and will go into operation *in two years.*

The Calcutta and South-eastern Railway, uniting the former place with the new port which is being established on the Mutlah River, has now nearly reached completion, as we learn from the journal above quoted. The two most interesting features in this work would seem to be, first, the bridge over Tolly's Canal, a single skew span of 128 feet, which was composed of two wrought iron girders, constructed on the shore, and put in place by supporting one end on a framework 24 feet high, erected in a cargo flat, and running the other out on wheels traveling on rails laid up to the abutment; second, the crossing of the Pyallee River, where the existing stream was filled up, and a new and straight channel cut and bridged.

The Victoria Bridge, over the Thames, at Battersea, has been widened by the addition of another bridge on independent foundations, but corresponding in profile with the old one, and finished on the outer side with the facings removed from the former, thus producing, in fact and appearance, a single bridge, with a total width of 132 feet, thus accommodating 7 lines of railroad, and leaving 33 feet available for platforms, &c. The details of construction are very different, however, in the new and old bridges, the girders being so arranged in the latter as to act like arches thrusting upon the piers, while in the former they are continuous, and exert only a vertical pressure, thus allowing the piers in this case to be built without the extension at the foundation required in the other. A full account of these and other points will be found in the August number of the *Mechanics' Magazine.*

The removal and replacement in a new position of the iron columns supporting a large cotton mill in Manchester, without interruption to the work of the establishment, was lately described in a paper read before the Institute of Civil Engineers by Mr. William Fairbairn.

The application of steam plows seems to have met with marked success in some parts of England, as we are informed by Mr. Edward Brown, who has just returned from a visit to that country.

In one village of Huntingdonshire two sets of apparatus for this work are in use, one of these being owned by a man who makes his living by its means, plowing with it at the price of £1 per acre.

In these cases two engines are used, one being placed on each side of the field, and each changing its place while the plows are being drawn over the field by the other. By this means much time is saved, and when the loss by friction, by wear of ropes, &c., involved in working with one engine and anchors is considered, there is found to be even a gain in economy of working.

Improvement in steel pens and pen-holders, by Geo. Stimpson, Jr., 37 Nassau St., New York. This improvement consists in a peculiar shape, by which great strength and elasticity is secured, and of a simple arrangement, by which a tongue-like blade is caused to

protrude from the holder, and thus at pleasure convert the ordinary into a fountain pen, while, by reason of the same arrangement, the pen can be cleaned with the greatest facility. Many specimens of writing, illustrating the capacities of these pens, were exhibited, and on trial the improvement showed itself to merit all that was claimed for it.

A new gas engine, by M. Pierre Hugon, of Paris, has been lately put in operation in London. We cannot see, from the description given, that it differs in anything but a few details of construction, from the engine of Lenoir. With an engine of $2\frac{1}{2}$ horse power, it appears that about 74 cubic feet of gas are consumed per horse power per hour, or, at $3 per 1000 cubic feet, 21 cents per horse power per hour.

The steam syphon pump, a modification of the Giffard injector, seems to be performing very efficient work. The instrument in question consists of a globular vessel, into which, open from above, one, and from below two, large water pipes, in directions corresponding to those of the lines of an inverted letter Y, thus ⅄. Between the two lower branches enters a steam-pipe, which discharges steam upwards towards the other pipe. By this means water is drawn in through the two lower and expelled by the upper tube. The steam-pipe, curving around the ball, has given the name syphon to the arrangement.

Experiments with these pumps were lately made at the New York Navy Yard, by order of Commodore C. H. Bell, and the report thereupon was most favorable, as will be seen from the following extract:

The above data show that the syphon pump raises, in a given time, 41·7 per cent. more water than (the steam) pump having the same area of discharge, and in doing so consumes 48 per cent. more coal; therefore, in economy of fuel, the two kinds of pumps are nearly equal, but the syphon pump has superiority in the large bodies of water it can discharge in a given time, in its cost, in occupying less room in a vessel, in its not being liable to get out of order, its certainty of action, and unusual simplicity, there being no valves nor pistons to get deranged or choked by chips or dirt.

We unhesitatingly recommend it for relieving the holds of vessels from bilge water, and for discharging ashes from the fire-rooms.

We also recommend that the one now on board the Narraganset be retained and paid for.

Very respectfully, your obedient servants,

J. W. King, *Chief Eng., U.S.N.*
Thos. J. Jones, *Chief Eng., U.S.N.*
Geo. W. Stivers, *2d Asst. Eng., U.S.N.*

Commodore C. H. Bell, *U. S. N.*,
Commandant Navy Yard, New York.

PHYSICS.—Artificial stone, by Ransome's process. A large number of articles in this material were sent for exhibition by G. W. Norris, Esq. The process having been previously described in this journal, in quotations from foreign magazines, a brief notice only is here given. To the necessary quantity of clean dry sand, one-tenth part of concentrated solution of silicate of soda and one-tenth part of

pulverized flint is added, and the whole thoroughly commingled in a mixing mill. The soft material is then packed in moulds to give it the required shape, is taken out, "basted" with a solution of chloride of calcium, and boiled in a solution of the same, by which means a silicate of lime and chloride of sodium or common salt are formed in the stone by the double decomposition of the silicate of soda and chloride of calcium. The salt is then, in the last case, removed by a shower-bath applied for 12 hours, or more if necessary.

Specimens were exhibited of the material thus prepared, formed into vases, columns, ballistrades, ornaments in relief, such as heads, flowers, scrolls, &c., which showed remarkable delicacy and sharpness, and admirable strength, enduring heavy blows with an iron hammer.

This stone is to be largely employed in the construction of the grand hotel, Central Park, New York. The following certificate, made in the interest of the architects and constructors of this building, must carry much weight:

G. I. F. Bryant, Esq.

Dear Sir: I have made an examination of "Ransome's Patent Concrete Stone," which you brought me, and find that its absorbent power for water, when treated first in vacuo and then under atmospheric pressure under water, is, on three trials, per cent:

15·65
15·70
16 04
3)47·39
mean of the 15·79 three trials.

Mr. T. H. Henry's sample gave 17 per cent. as the quantity of water absorbed; so the samples I operated upon are better than his. Since it is as firm as any sandstone used in this country, and possesses no more absorbent power, it seems to me to be suitable for any exposed ornamental work on buildings. Mr. Henry's test by sulphate of soda having shown no disintegration will take place from frost, I think you may safely adopt this cement stone in architecture, as you have proposed, for exterior as well as interior parts.

Respectfully, your obedient servant,

Charles T. Jackson, M.D.,

State Assayer to Massachusetts.

N. B.—The length of time of immersion of my specimens in water, after the removal of air from the pores, was twenty-four hours.

Boston, March 13, 1866.

An article speaking in very strong terms of the excellence of this material will also be found in one of the late numbers of the *Engineer*, not to mention other articles which have before been published in most of the foreign magazines.

A new regulator for the electric lamp has been lately invented by M. A. Gaiffe, to whom a prize has been awarded by the Society for the Encouragement of National Industry. A report on

the subject by Du Moncel in the *Bulletin* of the Society, February, 1866, gives a full account of the apparatus in question. Its important feature is this, that the motion of the carbon points toward each other is not controlled by a fixed escapement, but by the action of an helix, which tends constantly to draw one of the poles into itself. By reason of this it is possible to adjust the position of the poles while the machine is in action without interruption, or the use of complicated machinery.

A process for staining wood, by Barton H. Jenks, with many specimens of its effects, was next described and exhibited. The wood to be treated is placed in a closed vessel, which is connected with an air-pump, and the air is removed. The coloring fluid is then allowed to enter and permeate the wood, which it does in a very thorough manner, on account of the removal of all air from the fibre. The excess of fluid is then pumped out, or the wood is removed and allowed to dry in the usual way. The specimens exhibited were all of white pine, and were stained with the following substances:

1.	Nitrate of iron	Warm gray, light.
2.	Nitrate of iron and paraffin	Warm gray, dark.
3.	Sulphate of iron	Colder gray, light.
4.	Sulphate of iron and paraffin	Colder gray, dark.
5.	Sulphate of iron and logwood	Like 3.
6.	Sulphate of iron, logwood, and paraffin	Like 2.
7.	Chromate of potash	Yellow gray, light.
8.	Chromate of potash and paraffin	Yellow gray, dark.
9.	Bichromate of potash	Yellow gray, between 7 and 8.
10.	Bichromate of potash and paraffin	Very rich yellow gray.
11.	Logwood	Light orange.
12.	Logwood and paraffin	Dark orange.
13.	Aniline blue	Bluish slate.
14.	Aniline blue and paraffin	Bluish slate, dark.
15.	Aniline red	Violet with yellow shade.
16.	Aniline red and paraffin	A little darker than 15.
17.	Aniline solferino	Rich purple.
18.	Aniline solferino and paraffin	Rich purple, darker.

The blocks exhibited were sections cut from larger sticks after treatent, and show the color to have penetrated very evenly and thoroughly.

Persistence of vision, in reference to the different colors of the spectrum, has been lately studied by the Abbé Laborde, who finds the more refrangible colors, such as blue, to be most persistent, and the others to be less so, red being the least.

Several instantaneous photographs, made by Mr. J. C. Browne, of Philadelphia, were then exhibited in the lantern. These pictures are remarkable for their perfect sharpness of definition and artistic effect. The light and shade in the clouds are such as an artist would select from his memory or imagination as best adapted to pictorial effect, while the moving objects, such as steamers crossing the view at full speed, sail-boats, figures, birds, and rippling waves, are given with a sharpness of outline and minute accuracy of detail which could not be surpassed in an ordinary sun-picture of a perfectly quiet object. These pictures are taken with the ordinary collodion. The instantan

eous production of the impression is obtained by the use of a large stop, by which much light is admitted to the lens. The aperture used in these pictures taken in the bright sunlight is, in fact, the same which would be employed for the subdued light of a room. In the latter case, an exposure of some 5 to 15 seconds would be required, while in the former the brighter light reduces it to a fraction of one second, or makes it practically instantaneous.

These facts are mentioned because there is a common, though false, impression that it is to some peculiar sensitiveness of the collodion that these instantaneous pictures owe their existence.

Several glass positives of the moon, made by Mr. Oscar G. Mason, of New York, from the world-famous positives of Mr. Rutherfurd, were likewise exhibited in the lantern. These positives are of unusual size, being 7 ins. in diameter, and some of them show portions of the lunar surface on a scale of 30 ins. to the moon's diameter.

These glass pictures were admirable in their sharpness, strength, and transparency, and their projections on the screen had all the beauty of porcelain maps in relief.

The Megascope, an old and almost forgotton instrument, for the projection of images from solid objects, was then exhibited by a very simple change in the arrangement of the lantern just used, involving no new parts; and the image of a hand was produced upon the screen of gigantic proportions, but with all the color, relief, and motion of life. Such arrangements as these are well adapted to the display of a few curious experiments, such as the above, but the great loss of light, and difficulty of obtaining anything like a flat field, renders them incompetent to compete with the common magic lantern for ordinary purposes.

CHEMISTRY.—A delicate test for nitric acid is supplied, as we learn from a paper by Mr. W. N. Hartly, in the *Chemical News*, by a simple galvanic combination, made up of a piece of platinum foil and a bit of magnesium wire. The foil is wrapped in ozone paper, (*i.e.* paper soaked in starch containing KI,) and a bit of magnesium wire is wound about this, being brought into contact with the platinum above the paper. This being dipped in the liquid to be tested, which has been slightly acidulated with sulphuric acid, peroxide of nitrogen was developed if any nitric acid was present in the solution, and stains the paper purple by the liberation of iodine.

The oxidizing power of the permanganates renders them, as is well known, very efficient deodorizers, but it is well to call attention at this time to their power as disinfectants. It appears, from experiments made by the Commissioners on the Cattle Plague, that these salts, added in small quantities to water containing injurious organic matter, completely destroy the same, and render the otherwise poisonous fluid wholesome. It must, however, be remembered that time is required for this action to be effected, and that without this element in the treatment, water may continue to hold the most injurious and disgust-impurities, even when strongly colored and unpleasantly flavored with the permanganate.

Mr. Coleman Sellers here remarked that the change of color produced by the action between permanganates and organic matter, afforded a valuable indication of its effect. Thus, a little of the red solution being added to offensive stagnant water lost its red color and assumed a green, being, in fact, reduced from a per-salt to a lower degree of oxidation, and that, therefore, the action should be continued, and an addition of the solution made until the red color was unaffected.

The deodorizing properties of these salts were very marked, and with this view they were frequently used by dentists in their practice; a solution whose color would hardly attract attention being very efficient in this respect.

Mr. R. Tighlman remarked that it was of great importance not to overlook the statement made in the Report of the Commissioners, already quoted by Prof. Crookes, that the mere addition of permanganate did not suffice to destroy animalcules or other organic germs, since many of these were shown by the microscope to exist in water strongly colored by the above salts. This was of importance, because an impression of security without foundation was otherwise given, which would lead to disasterous results, inducing people to use water with the disinfectant solution, under the impression that all must be right, when, in fact, it was in a most unwholesome and noxious state.

But if carbolic acid were first added and then permanganate, destruction of all organic matter must be accomplished.

Some remarkable statements concerning the deutoxide of hydrogen have been made by Schönbein in the *Journal für Praktische Chemie.* Thus, he states that the "solution may be concentrated by boiling," whereas it has been generally stated that this solution is decomposed explosively at 212° F. We also read that this compound may be completely dehydrated by evaporation under the air-pump, and that paper drenched with a solution containing but $\frac{1}{2}$ per cent. may be dried, and will yet show the characteristic tests for this substance; results which would hardly be expected from the description of Thènards.

A new process for the manufacture of oxygen, lately patented in England, is described as follows: Oxychloride of copper is mixed with sand, or like material, to prevent it from vitreous fusion, and is then heated to redness in an earthen retort, when its oxygen is disengaged. It is then, on cooling, removed, broken into fragments, and exposed to the air for 12 hours, when it is found to be revivified or reoxygenated, and is ready to be again heated as before. Such a plan, if really successful, would be very valuable, but would require operations to be conducted on the large scale to realize its advantages. This has seemed to be the drawback to the similar process in which binoxide of barium is first reduced by heating in a current of steam, and then reoxidized by a current of air, and which never appears to have been practically developed, though recommended by very high authorities.

A paper on flame reactions, by Bunsen, has been translated by Prof. Roscoe, and published in the last number of the *Philosophical Magazine.* From this it would appear that all ordinary blow-pipe reactions may be shown with the best effect and great convenience by

the use of a Bunsen burner properly constructed. For the details of the burner and its applications, we must refer to the the original paper, or to an abstract of the same in the August number of the *Mechanics' Magazine*, page 67.

Phosphorus may be removed from iron, as is stated by Carl H. L. Wintzer, of Hanover, if chloride of calcium is added to the metal while on the hearth of the puddling furnace. A chloride of phosphorus is then formed, which, by reason of its volatility, quickly leaves the other materials, and the lime fluxes with silicious matters.

The deposits of cubic nitre, or nitrate of soda, generally supposed to exist in Chili, but really found in Peru, are very fully described by Mr. David Forbes, in a paper upon Peruvian minerals, published in the *Philosophical Magazine*. These deposits occur along what seem to be the shores of an ancient chain of shallow and very irregular lakes, which are now perfectly dry, barren, and desert. This deposit is found only along the shores, the central parts containing only sea salt. This suggests and substantiates the conjecture that they are the result of decomposition, under peculiar conditions, of the marine vegetation which must formerly have lined these shores. Even the land growth must at one time have been most luxuriant, for ancient wood is found in such quantity in this locality that until lately it was the only fuel used in refining the salt, and is yet largely employed for this purpose.

At the conclusion of the Secretary's Report, Mr. Nystrom made the following remarks on a composition of cast iron and steel, and also on the heating of journals in propeller engines:

Mr. President: I have read in an English journal an article relating to a composition of cast iron and Bessemer steel, said to produce a hard metal, and used for casting steam cylinders. A few years ago, when experimenting in the pneumatic process of refining iron, I produced similar compositions, of which here is a specimen. My object was to produce a tough metal for casting guns, and I found that different proportions of cast iron and pneumatic steel gave different grades of toughness and hardness. About one part of steel to three of cast iron I thought would be the best proportion for guns. I stated the case to some functionaries in the Navy Department about four years ago, but did not succeed to impress upon them its importance. This specimen contains about half cast iron and half steel—it is so hard that it cannot be cut by any steel tool. Its specific gravity is 7·56, which is nearer wrought iron (7·78) than that of cast iron, (7·20.)

This specimen is a piece of a lid for a blast-pipe, in which it was intended to drill some holes, but was found so hard that the hardest cast steel drill did not touch it in the least. I then annealed it in a charcoal fire for twenty-four hours, and let it cool very slow and gradually, by which the toughness was considerably increased, but the hardness remained nearly the same as before, so that I still could not drill the holes, but was obliged to cast another lid of the same cast iron without steel.

This composition can be advantageously used for a great many purposes in the mechanic arts, as for steam cylinders, packing-rings for steam pistons, slide-valves, guides, and tool-slides, rollers for hard metals, grist-mills, guns, face-plates, and wherever a hard and tough metal is required. When the composition is made as hard as this specimen, it cannot be cut by steel tools, but if the object is not too complicated it can, in many cases, be ground to a true surface by sand-stone and emery.

I believe this composition can remove a great difficulty involving millions of dollars in this country, namely, the heating of journals in propeller engines, which now controls, to a great extent, the success of that machinery.

In order to overcome this difficulty, Chief Engineer Isherwood has introduced very long journals, from two to three times the usual proportions, which would apparently lead to satisfaction, but experience has not fully realized the expected result, and upon reflection we are able to trace the difficulty attending the long journal, namely, to keep the bearing surfaces in proper contact and perfectly concentric.

The greatest difficulty appears to be in the crank-pin journal, where the space is generally so crowded that the desired length cannot be obtained, but if fitted with boxes of this composition of cast iron and steel, I believe the difficulty would be overcome.

The heating is occasioned by excessive pressure and velocity in the journal surfaces (dynamic momentum) necessary in the short stroke direct action propeller engines. When the journals begin to heat, the iron beds itself into the box, crushes its texture, and excludes all lubricating substance from the surfaces in contact, so that even if the journal was wholly immersed in oil, the heating could not be prevented, but sometimes becomes so strong as to actually melt the metal, which could not be the case with this composition.

The cast iron and steel boxes should necessarily be carefully ground and fitted on the journal; and, in order to secure a perfect bearing in the whole length, it should also be spherically fitted in the stub end.

For the main journals it would not answer to fit cast iron and steel boxes as the brasses are now fitted. The cast iron and steel boxes should be fitted spherically in the plumber-blocks, and if properly executed there would be no trouble of heating. The length of the journal should be made equal to or not more than $1\frac{1}{4}$ times its diameter.

Another serious obstacle for preventing the heating of journals is the difficulty of procuring a uniform iron in the forging of a crank-shaft or crank-pin. The pneumatic process of refining iron known as "Bessemer's," by which ingots can be cast into a homogeneous mass, may fully remove that difficulty, and it is very satisfactory to know that we are now able to procure such castings in this country, as seen in the advertisements of the Albany Iron Works, Troy, N.Y., where it appears the Bessemer process is now brought to a successful operation.

In our present trouble we are often obliged to slack the speed of the propeller engine for heating of journals, which proved a serious

hamstring during the war, in chasing blockade-runners, which were often lost on that account.

The excessive dynamic momentum to which the cranking journal is subjected in propeller engines, can be sustained better by cast iron than by brass, for the following reasons:

PROPERTIES OF—	Cast iron and steel.	Brass.
Crushing weight in tons per square inch............	125	63
Expansion per unit of heat...........................	618	1040
Conducting power for heat............................	300	700
Specific heat..	120	93
Smelting point.......................................	2900°	1900°
Cost per weight......................................	1	10

All these data are in favor of cast iron and steel for sustaining great dynamic momentums in journals. It should be clearly distinguished between the dynamic momentum acting to heat the journal and that transmitted through the propeller-shaft, as they bear no fixed proportions.

The cast iron and steel can sustain double the crushing weight, and is twice as hard as brass, but this fact does not constitute the superiority of the former over the latter, for a brass composition can be produced which is as hard as steel, and sometimes used for dies; but the advantage of cast iron lies in its uniformity of texture, even if made of the same hardness as brass.

The expansion by heat throws the box and its bearing surface out of shape, which evil is greater in brass than in cast iron and steel, and the uneven texture in brass makes some parts expand more than others, by which projections are raised in the wearing-surface which start the cutting of the journal.

The conducting power stores the heat in the box, and renders the brass sooner heated than by cast iron and steel.

The specific heat resists the temperature of the box; that is to say, it requires more dynamic momentum, or more units of heat, to produce a certain temperature in cast iron and steel than in brass.

The work converted into heat in the brass boxes will, to a great extent, be transmitted through the cast iron and steel boxes to, and utilized by, the propeller.

The friction in cast iron and steel boxes would be considerably less than that in brass or Babbitt's metal.

The difficulties about the cast iron and steel boxes would be that they require a more careful fitting on the journal at the outset, and that they are liable to rust when the engine is at rest. But a careful engineer will overcome these difficulties.

Mr. Washington Jones remarked that "there is no difficulty about heating of the journals. Sometimes they heat and sometimes not. It is only required to make the bearing-surfaces sufficiently large for the pressure."

Mr. Coleman Sellers remarked that "cast iron bearings work very well, and perhaps better than brass."

The meeting was then, on motion, adjourned.

HENRY MORTON, *Secretary.*

BIBLIOGRAPHICAL NOTICES.

Canada Geological Survey.

The library of the Franklin Institute is indebted to the provincial government of Canada for a copy of the atlas of maps and sections intended to accompany the volume on the Geology of Canada, which appeared in 1863. It consists of five colored maps, with accompanying sections, intended to illustrate the arrangement of the Canada rocks, and their connexions with the formations in the United States. Although the general maps are on a very small scale, yet the great precision of their execution, and the careful manner in which they are printed, render them better for reference than larger and more pretentious maps, in which these good qualities are not found. The extreme care which has been taken to obtain the best possible information from the most authentic sources, and the high reputation which the survey has made for itself by its accuracy, render the work to which this is an appendage one of the most valuable aids to the geologist.

Coal, Iron, and Oil; or, the Practical American Miner. By JAMES HARRIES DADDOW and BENJAMIN BANNAN. Pottsville: Bannan, 1866. 8 vo., pages 808. Maps.

This is a very valuable work, presenting in an interesting form a great amount of information on the subject of the coal, iron, and oil mines of the United States and elsewhere, and giving at the same time both a practical and theoretical treatise on the subject of their formation, occurrence, and method of working. It is well illustrated by cuts, presenting views, diagrams, and sections, and contains a large and apparently excellent map of the anthracite districts of Pennsylvania. The principal author of the work (Mr. Daddow), in his preface, asks especial attention to his three new theoretical propositions, which are—

"1. That the material forming both the Azoic and Palœozoic formations of the earth are almost exclusively and directly from volcanic sources.

"2. That volcanic and subterranean heat produced the vapors or gases which resulted in petroleum, naphtha, &c.

"3. That the hydrocarbons, in the shape of naphtha, petroleum, and their resulting bitumen, formed mineral coal."

We do not think any good observer, after carefully examining our rocks, will be disposed to agree with the authors in any one of these propositions, but cannot here go into the arguments to show the contrary. All we can say is, that, supposing these theoretical propositions to be wrong, they detract but slightly from the great value which the care and industry of the authors have given to the work.

A Comparison of some of the Meteorological Phenomena of SEPTEMBER, 1866, *with those of* SEPTEMBER, 1865, *and of the same month for* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	September, 1866.	September, 1865.	September, for 16 years.
Thermometer—Highest—degree,	91·00°	89·00°	95·00°
" date,	3d.	4th & 6th.	12th, '56.
Warmest day—mean,	82·00	82·50	85·20
" " date,	2d.	12th.	6th, '54.
Lowest—degree,	50·00	49·00	39·00
" date,	16, 22, & 23.	19th.	25th, '56.
Coldest day—mean,	57·17	56·83	51·30
" " date,	22d & 23d.	19th.	30th, '53.
Mean daily oscillation,	14·30	11·90	16·04
" " range,	4·97	4 81	4·70
Means at 7 A. M.,	65·13	70·73	63·27
" 2 P. M.,	75·65	77·85	74·68
" 9 P. M.,	68·22	73·42	67·08
" for the month,	69·67	74·00	68·34
Barometer—Highest—inches,	30·155 ins.	30·225 ins.	30·430 ins.
" date,	16th.	28th.	16th, '51.
Greatest mean daily press.	30·101	30·169	30·381
" " date,	16th.	27th.	16th, '51.
Lowest—inches,	29·520	29·583	29·281
" date,	21st.	6th.	18th, '63.
Least mean daily press.,	29·608	29·672	29·453
" " date,	12th.	6th.	16th, '58.
Mean daily range,	0·133	0·109	0·122
Means at 7 A. M.,	29 842	29·950	29·950
" 2 P. M.,	29·786	29·888	29·907
" 9 P. M.,	29·828	29·933	29·939
" for the month,	29·819	29·924	29·930
Force of Vapor—Greatest—inches,	0·864 in.	0·874 in.	0·991 in.
" date,	2d.	14th.	6th, '54.
Least—inches,	·243	·256	·161
" date,	23d.	19th.	29th, '60.
Means at 7 A. M.,	·530	·604	·480
" 2 P. M.,	·562	·621	·591
" 9 P. M.,	·585	·631	·520
" for the month,	·559	·618	·530
Relative Humidity—Greatest—per ct.,	95·0 per ct.	93·0 per ct.	100·0 per ct.
" date,	20th & 26th.	18th.	2d, '54.
Least—per ct.,	46·0	36·0	29·0
" date,	22d.	16th.	2d, '59.
Means at 7 A. M.,	81·3	77·4	78·3
" 2 P. M.,	61·1	63·5	56·7
" 9 P. M.,	81·8	74·6	74·5
" for the month	74·7	71·8	69·8
Clouds—Number of clear days,*	7	8	10·8
" cloudy days,	23	22	19·2
Means of sky cov'd at 7 A. M.,	74·3 per ct.	73·0 per ct.	58·2 per ct.
" " " 2 P. M.,	50·7	55·3	52·4
" " " 9 P. M.,	52·0	32·7	37·0
" " for the month	59·0	53·7	49·2
Rain—Amount,	7·457 ins.	6·576 ins.	4·441 ins.
No. of days on which rain fell,	11	10	8·4
Prevailing Winds—Times in 1000,	N47°17′ W ·105	S63°26′ W ·167	S89°20′ W ·179

* Sky one-third or less covered at the hours of observation.

JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

DECEMBER, 1866.

CIVIL AND MECHANICAL ENGINEERING.

The Festiniog Railway.

From the London Civ. Eng. and Architects' Journal, September, 1866.

(Continued from page 323.)

Mr. G. P. Bidder, Past President, said he had listened to the paper with great interest. It was an evidence that the author, as a government official, had a view to the commercial results of railways. This system was not propounded as a measure of economy, in other respects than that there were cases in which the economy of constructing the narrow gauge should be considered, where it could be introduced, for the sake of the curves and gradients, in districts where the broader gauge could not be introduced. That was the only ground on which this question could be fairly considered; but the author did not pretend that a narrow gauge could be worked more cheaply than a broad gauge. The arguments adduced in favor of the economy of working the narrow gauge, if followed out, would lead to the conclusion that, if there were no gauge at all, a railway could be worked for nothing. The question was, not the cost of moving a carriage, but at what cost a ton of minerals, or coals, or a hundred passengers could be moved. As a matter of practice, a ton of minerals, or a hundred passengers, could not be moved on a narrow gauge more cheaply than on a broad gauge. That it was so in this case was shown in the figures given in the paper; for although the substitution of steam traction in place of horses was undoubtedly a proper thing to do, yet he did not understand the author as propounding the question of these narrow gauge railways to show that the cost of working, ton for ton, and passenger for passenger, was any cheaper than

working on a broader gauge. The author said distinctly, he did not propose this narrow gauge, except in isolated places, as in the instance given between Festiniog and Portmadoc, where the railway took the slates from the quarries to the ships, and had no connexion with any other railway. But a break of gauge, whether in India or elsewhere, was an avowed evil and could only be reconciled by the advantages of economy of construction, as compared with the cost and inconvenience of transshipment. As to these railways, he had no doubt for short branches or extensions, or even for village lines, it might be useful to introduce them. But in this country there were what were called the "Standing Orders of Parliament," which interfered very much with such lines. Engineers were allowed to deviate 5 feet vertically in open country, and were restricted to 2 feet in towns. Anything more absurd than that, it was impossible to conceive. In the neighborhood of London, where the country was flat, a limit of 5 feet might be suitable; but in districts where the inclination of the surface of the ground was 1 in 5, or 1 in 6, the 100 yards of lateral deviation might change the work from cutting to embankment; and the 5 feet might require to be 20 feet, or 30 feet. Parliament said, "A railway shall not cross a public highway in this country if it interferes with its level, excepting it be made with a gradient of 1 in 20 for a parish road, and 1 in 30 for a turnpike road; nor shall it cross a road on the level, without permission." Of course, these were questions of local circumstances: 1 in 20 might be a proper gradient for London; but there were districts where the normal gradients were 1 in 7 or 1 in 10, and where the traffic might amount to three vehicles, or four vehicles per day. No attention was, however, paid to that fact, nor were the reasons listened to, but a gradient of 1 in 20 was insisted on. He had had to say, on one occasion, in committee, that if such conditions were to be abided by he could not prove the preamble, for the gradient of the valley 1 in 11, 1 in 20 would go quite across the valley. But what he proposed was, to spend £500 in improving the road on the other side of the railway, leading to the nearest village, and then the bill was passed.

With regard to level crossings, he feared he had been a great offender, for on one line he had as many as thirty-eight level crossings on as many miles of railway. But now the rule was, that there should be no level crossings. In consequence of this, where the Great Eastern Railway crossed a country road at its apex, at a most convenient place for a station, especially for minerals, the engineer was compelled to avoid making a level crossing, though it was near the highest point of the country, and to raise that road 15 or 16 feet, at a cost he believed of £7000 or £8000. The company could not have a station there, the opening of the line was delayed for several months, and the thing was a nuisance to the neighborhood.

He offered these remarks, because this paper showed, that the author's mind was directed to commercial results. He said in effect "where the broad gauge is inappropriate have a narrow gauge." He agreed with him; but the question of commercial consideration entered as much into

broad as into the narrow gauge railways, and regard must be had to the local circumstances where each gauge might be applied.

Mr. E. Woods thought it was evident, from the observations which had been made, that no one system could be laid down, nor any one gauge be fixed upon, as applicable to all conditions of locality, traffic, &c., but that each district must be treated according to its circumstances. With regard to the Indian gauge of 5 feet 6 inches, he could quite understand, it was most desirable to construct branch lines on the same gauge as the main lines, and in a flat country like India the difference of cost as between a gauge of 5 feet 6 inches and a narrower gauge would not be great, the principal item being in the additional length of the cross-sleepers. The rails might be lighter than those of the main line, and the engines for working the branches made light in proportion. Six years ago he had to construct a railway in Chili, 27 miles in length. The line was situated in the lower range of the Andes, where the gradients were necessarily severe and the curves sharp. Here curves of 500 feet radius, in combination with gradients varying 1 in 20 to 1 in 30, constantly occurred. It was said, by the engineers of the country, that it would be impossible to work that line with locomotives, and accordingly it was laid out for mule traffic, and it was worked by mule power for eighteen months. But owing to the seasons, of drought, and other causes, the expenses of working were so high, that a decision was come to by the Directors to work the line by locomotive power. He was called upon to design the engines, and in his design he limited the weight on the driving-wheels to $7\frac{1}{2}$ tons, but the difficulty was to get sufficient adhesion to take the loads up the severe inclines of 1 in 20 for 7 miles, and of 1 in 30 for 12 miles. That difficulty was overcome by putting 6 driving-wheels to the engines, and placing the front end on a bogie truck. The rails, of 42 lbs. to the yard, had stood exceedingly well, and up to this time were in good working order, for though the engines weighed 30 tons, the weight, being distributed over so many wheels, had produced no sensible injury to the rails. The ordinary working speed on the inclines was about 12 miles per hour.

From the experience of the working of that line, it was evident that railways of light and inexpensive construction might be advantageously worked, if due regard were paid to the adaptation of suitable rolling stock.

Mr. W. Bridges Adams said, in dealing with the question of light railways, there were two aspects from which to regard them, the commercial and mechanical. The latter might be a toy, but the former must have reference to utility. The object being to transport materials and men, there must be sufficient volume in the carriages to hold them conveniently. Now, it was not convenient to have the dimensions so reduced as to render it necessary to strap the passengers to the seats to prevent oversetting. It was quite true, that the narrower the gauge the shorter might be the distance between the axles, if rigidly parallel, so as to facilitate passing round sharp curves; but, on the other hand, the longer the vehicle the steadier would it run, and the rigid structures which formerly needed straight lines of way or very flat curves, might now cease

to be rigid, by provision being made for the axles to radiate on curves, and point truly to the centres of those curves. By this arrangement, and by the use of spring-tires, permitting the wheels to slip within the tires, it was now practicable for carriages or engines, with extreme wheels 25 feet apart, to roll without rail friction round curves of 2 chains radius, and this fact rendered the width of gauge, whether 2 feet or 7 feet, a matter of indifference as regarded curves. On the Norwegien line of 3 feet 6 inches gauge, engines of that class were now working.

In considering the cost of gauge, the saving could not be in the rails, but only in the length of the sleepers and the quantity of ballast, bridges, &c. The axles might be shorter, and material might be saved in length of cross-framings, but it did not follow that this was economical. With a given load, there was a certain space required to stow it, and there was a certain proportion of length to breadth of train which gave the best results in traction. A long narrow train was disadvantageous, and especially so on very sharp curves. The proportion of the width of rail gauge to the width of the carriages was another consideration. As a mechanical rule, the carriage bodies might be safely made double the width of the gauge. Beyond that width there would be a tendency to unsteadiness. A 2-feet gauge, by that rule, would only admit a carriage 4 feet wide, and that, even with passengers back to back, was very cramped. Again, with passengers so placed, 3 feet in length of the carriages would only carry four passengers; while seated fore and aft eight passengers could be carried in a 4-feet length of carriage, with a 3-feet gauge of rails, *i.e.*, one-fourth increase in length of train would double the number of passengers or volume of goods.

With a 2-feet gauge and wheels 2 feet in diameter, the boiler and framings should be carried above the wheels altogether. With a gauge of 3 feet 6 inches, the boiler might be between the wheels; and engine-wheels of only 2 feet in diameter seriously damaged the rails if heavily loaded. If of larger diameter, better adhesion might be attained. The worst gradient on the Festiniog line appeared to be 1 to 60, but with heavier gradients heavier engines would be needed, and there was now no difficulty in constructing engines with eight drivers to roll round curves of 2 chains on any gauge. The very important feature in the engine described was the great pressure of steam—200 lbs. to the inch.

There was no doubt that narrow gauges might be made at less cost than wide ones, but it was doubtful if any material saving could be made by reducing a 3-feet gauge to a 2-feet gauge, when it was considered, that the upper structures of the train must be provided with sufficient space for convenience.

There was one reason why it was desirable to make branch lines of a narrower gauge than main lines when the traffic was light, viz: to prevent heavy engines and vehicles from running on and destroying them. But in the coal traffic it was desirable and possible to employ wagons of the greatest capacity and length, capable of running round the sharpest possible curves and up to the pit's mouth, and in this case it was better to have no break of gauge. On a gauge of 4 feet 8½ inches, it was quite

practicable to use 8-wheel wagons, 40 feet long, by 9 feet wide, with an internal capacity of 1500 cubic feet.

Mr. Gregory, V.P., said, he was prepared to recognise the propriety of the measures adopted on the Festiniog Railway, under circumstances which, he thought, were special and peculiar; but the Institution and the profession would be bold if they attempted, on the data now before them, to adopt, as had been suggested, the idea of a supplementary narrow gauge for all small branch lines. He believed that the advantage of such a gauge was limited to local conditions, such as those described in the paper. There was an old line having branches into several slate workings, and on account of the gauge already existing in those workings, and the character of the works and the curves of the Festiniog Railway itself, it would have been exceedingly difficult to adopt the ordinary gauge; therefore the managers had endeavored to make the most they could of an exceptionally narrow gauge, by converting the main line into a line for general goods and passengers. They also did well to introduce locomotive power on the line; but all who heard the paper must feel that this was done under difficulties. He must record his protest against the theory, that the cost of the working expenses of railways was in proportion to the cubes of their width of gauge. The quantity of goods, or the number of passengers to be carried, was an essential element in such a question, and he thought that it might with as much correctness be affirmed that Messrs. Pickford could carry on their business more cheaply in costermongers' carts than in their usual vans. This illustration would show that such a theory could not be practically supported. He was sure while Mr. England had got work out of an engine, under difficult circumstances, with an exceptionally narrow base, that gentleman would state that he could obtain greater power, and more economy for a large amount of work, if he had a wider base to work upon.

In considering the circumstances under which an exceptionally narrow gauge might be adopted, it became necessary to investigate its supposed advantages. Setting aside the idea of any saving in working, when there was anything beyond a very limited traffic, these advantages appeared to be classed principally under two heads, viz: first, a saving in cost of construction, and, secondly, the easier use of sharp curves.

What had been done on the Festiniog Railway to make the most of its capabilities did not point to much saving in first cost; indeed, it seemed, as had been remarked, that the saving would extend to little beyond sleepers and ballast. It was pointed out in the paper, that to make the most of the wagon and carriage room, the rolling stock overhung so far that a width of 4 feet 6 inches was required between the rail and any bridge piers, and a 7-feet space between any two lines of rail; the result would be the necessity for a minimum structure width for a single line of 11 feet, as compared with 12 feet 8 inches on the ordinary gauge, and for a double line a width of 20 feet, as compared with 23 feet 5 inches in the ordinary gauge of 4 feet 8½ inches. Such a difference would produce so small a saving in the cost of the works as not to compensate for the disadvantages of having a very narrow

wheel base, which would limit the power of the engine, and, in the event of the derangement of the permanent way, would cause such unsteadiness in running, that the speed common on ordinary railways would be dangerous.

With regard to curves, the friction arising from the different length of the arcs of the outer and inner rails was greater on a broad gauge than on a narrow gauge, and as rolling stock was at present generally constructed with rigidly parallel axles, the most obvious advantage of an exceptionally narrow gauge was the smaller radius of curves that might be adopted. But, he thought, modern improvements were going far to overcome the difficulties of sharp curves, and he recognised the great value of such inventions as Mr. Adams' radial axles, by the application of which to the ordinary engines and rolling stock of the country, trains might run round sharp curves on the ordinary gauge as freely as on a narrower one.

As these two supposed advantages seemed likely to disappear, he therefore concluded that, seeing the loss which took place by the uneconomical application of the power of the engine, the fact that the ordinary gauge admitted of rolling stock, which would bear a smaller proportion of dead weight to the weight carried, and, last but not least, the evils of a break of gauge, it might be concluded, that if there was to be an exceptionally narrow gauge in this country, it could only be advantageously applied to exceptional cases.

Mr. T. E. Harrison said, he entirely agreed that it would be absurd to say, because this narrow gauge had been successful in its application in a particular state of things, therefore it was applicable generally. The particular case where it was applied was one in which the main traffic of the line was in slates, and the trucks were taken to where the slate was quarried, and where no large wagon could go. The slate was unavoidably brought down inclined planes in narrow wagons, and, if the gauge of the main line had been broad, must have been reloaded into broad gauge wagons. At Portmadoc the slates would have to be again transferred from the wagons to the ships alongside the quays: this narrow gauge was therefore the best means of conveying them to the port of shipment. As to the mode adopted for the conveyance of passengers, no doubt it was ingenious, and people traveled on the line with a good deal of comfort; but the works were so narrow that, when the train was standing still in a cutting, a passenger could hardly make his way past the edges of the carriages. That was not a railway which could be taken as a sample of what was desirable. It was a clever adaptation of a state of things which previously existed, and which had been designed with a different object, and, as far as it went, it was exceedingly good; but to suppose that the principle upon which it was constructed was to be applied to an unlimited extent where railways of the ordinary gauge existed, was a total fallacy. It was possible that there were exceptional parts of the country where such a system might be adopted; but at the present moment such an instance did not occur to his mind. He knew there was an intention to employ the narrow gauge in other slate quar-

ries; but those were particular cases, and he thought, if the Institution gave its sanction in any shape or way to the extension of the system to general traffic, it would be leading the public in a wrong direction.

Mr. Alfred Giles remarked, that it was some years since the battle of the gauges was fought, and he had scarcely expected a fresh campaign to be opened in this Institution in favor of a 2-feet gauge. The 7-feet gauge was known to be too wide. Mr. Hemans had observed that the Irish gauge of 5 feet 3 inches was wider than was necessary, and Sir Charles Fox had said that, if he had had his own way in India, he should have preferred to have laid the branch lines on the national gauge of this country instead of on the gauge of 3 feet 6 inches. This proved that the old gauge was not far from the right thing. The advantages claimed for the narrow gauge were, first, great facility in traversing sharp curves; secondly, economy in construction; and thirdly, the use of lighter rolling stock. The first two points had already been disposed of. He remembered seeing in Paris, some years ago, a little railway with a gauge of 4 feet 8½ inches running in a circle, the radius of which, he believed, was only 25 métres. He had seen trains run round that line with great facility; and if that were so, where was the necessity of making a 2-feet gauge to save a little in the radius of the curve? It was stated that the least curve on the Festiniog line had a radius of 2 chains, or about 40 métres. As to first cost, it had been shown that the economy could result only in a little shortening of the sleepers, and a little saving of ballast. This could not be put down at more than £300 a mile. Then, as to the weight of the rolling stock, credit was claimed for the engine being only 7½ tons weight; there was no reason why an engine of similar weight (plus a little extra for the longer axles) could not be applied to the ordinary gauge. But it had been asserted, that the weight of the rolling stock was increased as the cube of the gauge. If that were the case, the weight of the Great Western broad-gauge engines should be 343 tons. Looking at all these circumstances, it was clear that the national gauge was nearly the best that could have been chosen. On an ordinary road, where there was no limit as to gauge, carriages had a width of about 4 feet 6 inches, and even the smallest cart was wider than 2 feet. He hoped, therefore, that engineers would not adopt the idea that the 2-feet gauge was an example to be copied, when they knew, as had been remarked, that a break of gauge was a great public inconvenience.

Mr. J. J. Allport, having had many years' practical experience in the working of railways, would offer but one observation upon this very narrow gauge. For reasons which he would state, he was of opinion that it would be most objectionable to attempt to introduce it into the country generally. With respect to the existing broad and narrow gauges, it was well known to all practical men, that the weight of a train on the narrow gauge was as great as on the broad gauge, or rather, that engines could be constructed to take as great weights on the narrow gauge as on the broad gauge; and if engines were made much heavier than at present, various difficulties, such as of wear and tear, would arise. But there was one difficulty greater than all: the principal part of the work

of a train was at the stations, in the loading, unloading, and moving of trucks and carriages from one part of a station to another, across turntables or traversers; and any one who had had experience at a station worked upon the mixed gauge, or solely upon one or other of the gauges, must have been struck with the great additional expense in working the broad-gauge plant at the station. It was not difficult for a couple of men to move a narrow gauge truck or carriage to any part of the station; but to shift a broad-gauge plant, horses must be employed. The capacity of the goods wagons and coal trucks upon the narrow gauge had been gradually increased from about the size of the Newcastle chaldron of 2 tons 12 cwt. up to 8 tons, 9 tons, and 10 tons, for the load; but he thought all narrow gauge managers had come to the conclusion, that from 8 tons to 9 tons for trucks was the maximum load that should be carried on the narrow gauge, with a due regard to economy and safety. If that weight for the load was exceeded, the wagon itself had to be made so much heavier, and then the friction was considerably increased, causing hot axles and other objectionable results, so that it was not uncommon to see these heavy wagons standing under their load, at various sidings and stations, waiting to be repaired. On the Midland Railway there were between 17,000 and 18,000 coal trucks at work; for a long time the capacity of these trucks was limited to 6 tons: now the capacity had been increased to 8 tons; but the company did not approve of greater capacity than that. He was of opinion, that, for all practical purposes, the gauge of 4 feet 8½ inches was the best, and superior to either the broad or the narrower gauge. But there was another important consideration: if a very narrow gauge were adopted, it could only be on branches connected with main lines. That would involve, in all cases, transshipment of passengers, goods, and coals at the junctions; and in itself would cause a greater annual expense than the interest upon the increased first cost of the line upon the uniform gauge of the parent lines, both in the purchase of land and the construction of rolling stock. That was a fatal objection to the introduction of any gauge, other than that of the line with which these branches were connected. He had no doubt that in a very few years the gauge of 4 feet 8½ inches, as being the best adapted to the commercial wants of this country, would be the only one in use.

Mr. Zerah Colburn said, this paper raised the question, how small could a locomotive be made to give practically useful work? In 1852 the contractor for a portion of the works on the Great Western Railway of Canada employed the steam excavator, which no doubt many present had seen in former days on the Eastern Counties' line. For that purpose he proposed to lay the temporary line on the 3 feet 3 inches gauge, and wagons were built to hold each 15 cwt. as a load. Mr. Colburn designed and built a small 4-wheel tank engine for working these wagons, and six other similar engines were afterwards built. The tank was placed under the boiler between the frames, and as the gauge was so narrow, the fire-box was placed behind the driving-wheels, and to correct the overhanging weight the tank was carried as far forward as possible. These engines weighed 6 tons only, with fuel and water, and could be

easily taken apart, for carriage over common roads, into three principal portions, of which the heaviest weighed hardly more than 2 tons. The cylinders were 9 inches in diameter, with a length of stroke of 16 inches; and the wheels, of 3 feet diameter, were placed 4 feet 6 inches apart from the centres. The engines worked well, although, of course, only at moderate speeds.

Mr. James Brunlees knew the Festiniog Railway well, and though he did not question the success of working locomotives on so narrow a gauge mechanically, he much doubted its success commercially. On the other hand, he believed that, beyond a certain limit, the wider the gauge the less would be the dividends; he looked upon that as an established fact. Some years ago he constructed a narrow gauge line from Portmadoc to Gorsedda, the length of which was 8 miles and the gauge 3 feet. The total rise in the 8 miles was 900 feet, and the cost per mile, including land, was £2000. The sharpest curve had a radius of 400 feet, and the down loads were worked entirely by gravitation. But passengers were not carried on the line; and although he had advised this line to be made on a narrow gauge, he was not prepared to recommend its further adoption, unless for exceptional purposes or for purposes similar to the one in question. The want of uniformity of gauge was a great drawback to traffic in many parts of this country, and hence any departure from the ordinary gauge would perpetuate and augment that drawback.

Mr. Galbraith said, there was one principal involved in the paper which had been lost sight of in the question of the gauges; that was, was there no room in this country, particularly in the agricultural districts, for cheaply constructed railways on the gauge of 4 feet 8½ inches? He thought there was. There were many cases where, by adopting sharp curves and a light permanent way, with light engines and level crossings at public roads, a railway might be laid down for £4000 or £5000 per mile, which would pay a fair dividend upon the outlay; and he hoped it would be impressed upon the members of the Board of Trade, that, in respect of branch lines, on which the traffic was light, they ought to relax the stringent requirements with respect to expensive permanent way and costly works to avoid level crossings. He had been engaged in laying out a line in Devonshire of the character he suggested. If heavy earthworks and bridges were to be encountered, it was impossible that the line could be constructed to pay a dividend at all. In parts of Devonshire there were small public roads, the traffic on which did not exceed two vehicles or three vehicles per day. To maintain, at a heavy cost, the principle of avoiding level crossings in such cases was, he thought, unwise. In many cases, railway companies erected cottages along the line for the plate-layers to be near their work; and there could be no objection to the wives of the men attending to the gates at such level crossings, in consideration of living rent free. He thought curves of 10 or 12 chains radius, and level crossings where the public traffic was light, might be fairly admitted on branch lines, which, when constructed at £4000 or £5000 a mile, might be made to pay a dividend. In such cases, a light rail of 40 lbs. or 50 lbs. to the yard might be laid

down, which would carry the ordinary carriages, if not the ordinary engines; but for short branches of 10 miles or 12 miles, one engine or two engines might be specially provided by the company to work the branch alone. Such a plan as that was far preferable to an exceptionally narrow gauge, causing a break between the branch and the main line, and the consequent transshipment of the traffic, and the supply of fresh plant in the shape of carriages and wagons to work the traffic when so transferred. This question having been now fairly raised, he thought it was a point which ought not to be lost sight of, and which was well worthy of consideration.

Mr. Peter Barlow said, that though he was not of opinion that the gauge of 2 feet was expedient, or that any gauge at all approaching it was correct, yet he considered that the same gauge could not be suited to every description of traffic. The gauge adapted to the costermonger's cart would not answer for Pickford's vans, and the gauge of ocean steamers would not suit the penny boats on the Thames. He thought the cost of constructing a line was very little influenced by the width of the gauge; but was rather influenced by the width of the carriages. It was desirable that a uniform gauge should prevail all over the country, and good reasons ought to be shown for deviating from the established gauge. At the same time, he hardly conceived it was a gauge suited to all circumstances, and cases might arise in which the local traffic might be better provided for by a narrower gauge. What led him to think so was the result given by the author, who had shown that an engine weighing only 7½ tons could take a load of 50 tons up a gradient of 1 in 60. On the metropolitan lines, engines of 40 tons were often employed for less loads; but the exigencies of a metropolitan traffic required frequent and light trains, with power to get rapidly into speed, and thus resembled the case of the penny boats on the Thames. He agreed with Mr. Gregory that there was little economy in the construction of these exceptional gauges, and he thought what was done upon the 2-feet gauge might possibly be done upon the gauge of 4 feet 8½ inches. Still, the fact of what had been performed by the locomotives on the Festiniog line was worthy of attention, and he thought the Institution was much indebted to the author for having brought the subject forward.

Sir Cusack Roney had seen the gauges of Canada and the United States, and had traveled upon continental lines in various parts of Europe. He had also had the opportunity of seeing the working of many branch lines, and he was thoroughly convinced of the desirability of a uniformity of gauge in all cases, between the branches and the main lines. He considered that the gauge adopted in this country was the correct and really practicable one. In most parts of Europe he had met with nothing but the narrow gauge: with one exception—where the line was worked by horse power.

Mr. Robert Mallet begged to offer one or two observations in explanation. He had not intended to say, that in choosing a gauge the choice depended upon the purely physical considerations he had brought forward, but, on the contrary, that the choice of gauge must depend upon

prudential conditions, and, amongst other things, primarily upon the question of traffic. To put an obvious example: If the whole traffic were to be of cubes of granite, or other stone, each of 20 tons weight, a railway of even more than 7 feet gauge might not be sufficient. Thus, at the harbor works at Holyhead, the contractor's gauge was 9 feet or 10 feet, being employed for the transport of blocks of 15 tons. But for certain conditions and amounts of traffic, a narrower gauge than 4 feet $8\frac{1}{2}$ inches would not only be sufficient, but would be found the most economical and advantageous. What he had stated with reference to gauge was, that it was a general physical fact, that both the first cost of the works, and of the rolling stock of any similar railways, and also the working expenses for the haulage of any total of traffic, must increase with the width of gauge and as a high function of it, and that this function would probably be very nearly in the ratio of the cube of the gauges. English railways with a gauge of 7 feet, and those with a gauge of 4 feet $8\frac{1}{2}$ inches, could not be compared in those respects, not being similar either in way or in rolling stock. Thus, as respected the wheels and axles, those of the Great Western were rather lighter, being obviously weaker than those used on the narrow gauge, and having only the same width of tread. In the case of the passenger carriages, as a whole, he found the bodies were nearly of the same breadth on the narrow gauge as on the broad; on the former the overhang was greater. It was thus impossible to establish any ratio whatever between the width of gauge and rolling stock, where there was no similarity of construction on the two different gauges.

With respect to the remark, that if the width of gauge were "nil" the cost of working would be also "nil," it should be remembered, that on such an assumption the traffic also became "nil" at the same moment; so that while the mathematical deduction might be true, it did not in the least touch the question of the relative economy of the narrow and the wide gauges.

Mr. George England said, he did not for a moment apprehend that the narrow gauge of the Festiniog Railway was regarded as having been brought forward as a pattern for universal adoption. That line had been made fifteen years, and it was not originally contemplated that it would be worked by locomotives. During the time that the traction was performed by horses, the owners were satisfied both with the mode of traffic and the dividend the line yielded; and it was only when another company wished to take a wider gauge into the district that the working of so narrow a gauge by locomotive power was determined upon. It was done solely in self-defence: and he was applied to to carry out the object of drawing a load of 25 tons up an incline of 1 in 60 at the rate of six miles per hour. The first engine that was started took a load of 50 tons up the line at the rate of 12 miles per hour. That was simply the statement that the author had brought before the Institution. The line was 14 miles long in the incline: the wagons were taken into the slate quarries, and the locomotive was only adopted in order to suit local circumstances.

The valuable paper on the Festiniog Railway, which appeared in our last number, was read by its author, Captain Tyler, R.E., before the Institution of Civil Engineers, and the foregoing discussion thereon will be read with interest.

On the Connexion of Plates of Iron and Steel in Ship-building.

By NATHANIEL BARNABY, Asst. Const. of H. M.'s Navy.

From the London Civ. Eng. and Architects' Journal, October, 1866.

Much yet remains to be done to make iron ship-building a perfect art, and there is, perhaps, no one step remaining to be taken in the path of improvement more important than that of substituting a simple and efficient means of joining plates by welding, should it ever be discovered, for the present system of riveting. The loss of strength caused by the present system is considerable in iron, but appears to be still more serious in steel. It forms, in fact, the great bar to the introduction of this most promising material into ships of war. As an illustration of this, one or two of the many experiments which have been made by the Admiralty at Chatham Yard on Bessemer steel of the best quality may be given. A piece of steel 4 feet long and 12 inches broad, was cut from a half-inch plate, of which the proof strength was 33 tons per square inch. This piece was reduced to 5 inches in width at the middle, was supported at the ends by square plates riveted to it, and was carefully centered. The plate should have broken at $82\frac{1}{2}$ tons, and through the narrow part. It actually broke at $95\frac{1}{4}$ tons, and then, strange to say, broke through the wide part of the plate, tearing away through the rivet holes. Thus, while the material in the middle of the plate withstood a strain of 38 tons per square inch, it actually broke through the holes at 16·38 tons per square inch, or less than one-half the strain.

In a precisely similar plate, differing from the other only in the fact that the rivets connecting the end pieces were $1\frac{1}{4}$ inches from the edge instead of $2\frac{1}{2}$ inches. The plate broke in a similar manner at 73 tons, which is only 15 tons per square inch of the section of steel broken. The holes in both these cases had been punched, and, in order to ascertain whether these curious results were due to the injuries supposed to result from punching, an exactly similar arrangement of plates was again tried, in which the holes were, as in the first, $2\frac{1}{2}$ inches from the edge, but were drilled instead of being punched. The plate then broke through the narrow part at 106·75 tons, or 47·53 tons per square inch of the steel broken. I do not propose to draw here any inferences from the experiments detailed, or from the series of which they form part, further than this, that all which I propose to advance concerning the necessity of bestowing greater attention on the comparative strength of different modes of connecting plates intended to give tensile strength, is even more applicable to steel than to iron. Admitting, then, that, for the present at least, we must be content to connect iron plates by rivets placed in holes punched or drilled out of the material, and, therefore,

by the sacrifice of a considerable portion of the strength of the plate, it is manifestly the duty of the engineer and ship-builder to study to make this connexion with as little sacrifice of strength as possible. In every such connexion, the tensile strength of the plates across the outer line of holes, of the butt strap or straps across the inner line of holes, and the resistance of the rivets to shearing, should be all equal. Two plates may be connected, for example, by butt straps, so as to reduce the strength of the plate by one hole only. The strength of the several parts has, in this case, been estimated on the assumption, verified by careful experiment at Chatham, that the shearing value of a three-quarter Bowling rivet, including friction, and taken either singly or in conjunction with others, is 10 tons, and that of rivets of other diameters is in proportion to the squares of the diameters; also, that the tensile value of the iron between the holes is reduced in proportion to the number of the perforations, and that this reduction is about 25 per cent. when the holes are punched 3 or 4 diameters apart.

This description of butt strap is of no value in ship-building, because the stringer and tie-plates, to which it might otherwise be applied, have to be perforated between the butts by rows of holes to connect them with the beams. In such plates, in order to economize material, it is therefore desirable to reduce the amount of fastening at the beams as much as possible. I do not think it necessary to punch away for this purpose more than one-eighth of the iron. The remaining strength of the iron would then probably be $\frac{7}{8} \times \frac{7}{8} = \frac{7}{9}$ths of the whole, so that the straps connecting them should also give seven-ninths of the full strength of the plates. Any greater strength at the butts would, of course, be thrown away. If the butt strap has to be caulked, this proportion of strength cannot be retained, as the rivet holes must then be placed nearer together. I take, for example, the connexion by means of a butt strap of two plates $\frac{3}{4}$-inch thick and 12 inches wide, in which the rivets are 1 inch diameter, and are spaced three diameters apart. Then we punch out one-third of the iron, reduce the strength of the remaining iron about one-fourth, and have left only $\frac{2}{3} \times \frac{3}{4} = \frac{1}{2}$. The tensile strength of the plate at 20 tons to the inch is 180 tons, and the tensile strength through the holes about 90 tons. If the connexion is made by means of a single strap, the value of the rivets will be about 71 tons, and if by a double strap, 142 tons. No appreciable advantage could be obtained from a second row of rivets in this case, unless the spacing along the edge could be increased. If the rivets are no nearer together than is necessary for caulking, a second or third row would give no advantage, except in enabling us to reduce the thickness of the butt straps to less than the thickness of the plate, by reducing the number of rivets in the inner row where the butt straps are obliged to break. None of these considerations are new, but they have been so much neglected that those who are familiar with them will justify me in thus restating them. But there are certain other considerations equally important, which have altogether escaped the notice of ship-builders. Let us suppose that we have a stringer or tie-plate, the strength of which is, at the beams

and at the butts, $\frac{7}{9}$ of the full strength of the plates, and that we have no means of increasing the strength at these points. Have we any means by which we can, without altering the strength of these points, increase the tensile power of the plate? I think the answer would generally be, we have not. The strength of the tie will be measured by the strength at the weakest place, and this strength is fixed. What I want to show is, that this is not the case, and that we have overlooked an important element of strength, which is conducive to economy of material. Take the case of a stringer or tie-plate crossing a number of beams, say 3 feet 6 inches apart, at each of which the strength is reduced to seven-ninths of the full strength of the plate. If this plate is brought under the action of a steady strain it is a matter of indifference practically how many such points of weakness there may be, and how much stronger the material may be lying between the weak points. But when strains are suddenly applied, we have to consider not only the number of tons required to break the weakest section, but the amount which it would stretch before breaking. It is, in fact, the work done in producing rupture, viz: the force applied, multipled by the distance through which it acts, which is the true measure of the resistance to rupture. Under these circumstances no elongation will take place in the strong parts of the plate lying between the beams; it will all be thrown on the weak points, and if any one of these be weaker in any sensible degree than the rest, it will be confined to that point. This being the case a large increase of power may be obtained by reducing the strength of the plate between the weak points to the strength at these points, or even to less than this, provided we get long spaces of uniform strength to give elongation.

To illustrate this I will refer to some experiments made at Chatham with armor bolts, with reference to a proposal of Captain Palliser's. The proposal was to apply to armor bolts, having screws cut on them, the well-known principle that the bolts would be strengthened at the screw-thread, and become less liable to a break by a sudden jar, if the bolt, or a portion of it beyond the thread, were reduced in section to the same area as the iron left uncut at the thread.

The experiments referred to, made under my own careful observation, showed—

1. That iron bolts of good quality and of uniform diameter, subjected to a steadily increasing strain, elongate before breaking about one-fifth of their original length.

2. If the diameter is not uniform, but is decreased through a portion of the length, then the reduced part elongates about one-fifth of its length before breaking, and the larger portion scarcely stretches at all.

3. If this reduced part is very short, as in the thread of a screw, the strain required to break the bolt is the same per square inch of the unstretched or original section as in the previous cases; but there is scarcely any elongation before rupture.

4. If the whole length of the bolt is made to the reduced diameter

of the screw-thread, so that the thread projects from the bolt, the breaking strain (gradually applied) is the same as before, but as the bolt will stretch one-fifth of its length before breaking, it becomes thereby less liable to rupture by a sudden blow, because, as already stated, the work done in producing rupture is in proportion to the weight or strain applied, multiplied by the elongation or the distance through which it is applied.

The details of one portion of these experiments were as follows:

Four bolts were taken, all made of best selected scrap iron, for the purpose of the experiment, and all of the same diameter, viz: $2\frac{1}{4}$ inches, screw threads were cut in the ends of these and nuts fitted. The other ends were formed with heads, leaving a length of 21 inches between the heads and the nuts. The four bolts being thus as nearly alike in every respect as they could be made, two of them were reduced down on the anvil for a length of $4\frac{1}{2}$ inches in the middle of their length, to a diameter of $1\frac{7}{8}$ inches, which was the same as that of the iron remaining within the screw-threads. The two other bolts retained the full diameter throughout. They were broken in the hydraulic press, with the following results:

		Breaking strain in tons.	Sq. in. in sec. broken.	Tons per sq. in of this sec.	Elongation.			Where broken.
					In 5 ins.	In 15 ins.	In 2 ins.	
Bolts not reduced.	No. 1	63	2·76	22·8	Nil.	$\frac{1}{4}$	$\frac{1}{4}$	At thread.
	No. 2	69	2·76	25·0	Nil.	$\frac{5}{16}$	$\frac{1}{2}$ bare.	Do.
Bolts reduced.	No. 1	64	1·67	38·33	$\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	In reduced part.
	No. 2	65·5	2·07	31·58	$\frac{7}{8}$	1	$1\frac{1}{8}$	Do.*

The fact that the strains of greatest magnitude in a ship are sudden in their nature, makes the principle under consideration one of no slight importance, because we see that by its application we are able to increase the time during which a given force must be applied in order to produce rupture. As the material is disposed at present in iron decks, and stringer and tie-plates, the plates are perforated in the lines of the beams, not only by the holes required for the rivets to attach the plating to the beams, but by the deck-bolts which secure the wooden deck lying on the iron plating. The loss from the iron punched out, and the weakening of that which remains, amounts, on the whole, to from 30 to 40 per cent. of the original strength of the plates. These lines of weakness occur at intervals of about 3 feet 6 inches, and between them the plate has its full strength, except where a butt occurs.

The consequence of this is, that when the deck is put in tension, the stretching is confined to these weak places, and the amount of work

* At the shoulder where there was a slight defect.

which the whole combination is capable of doing before rupture is extremely limited. In order to remedy this state of things, I propose to remove all the wooden deck fastening from these weak places, and put it on either side of the beam. The number of rivets for attaching the plating I also propose to reduce. By this means a strength of plating is obtained across the lines of riveting of about three-fourths of the full strength of the plates. The next thing to be done is to reduce the strength of the plating between the beams to the same amount. This might be done by cutting holes in the plates; but instead of this I propose to omit the butt straps, and to arrange the plates so that in each of these spaces there shall be a continuous series of butts and plates, in the proportion of one butt for every three plates. In addition to this reduction of material, I propose to leave intervals between the butts of about one-third the distance between the beams, so as to get long spaces of uniform strength between the beams.

The length of the intervals between the butts will be determined by the number of rivets which can be placed in the edge of the butted plate between the beam and the butt, as there must be sufficient to break the plate across the beam. A short piece of edge strip on the under side doubles the shearing value of the rivets, and allows about one-third of the distance between the beams to be admitted. The advantages of one system over the other are, I think, the following:

1. In the ordinary system one-fifth or one-sixth of the iron is punched away: by that proposed only one-ninth or one-tenth is punched out. There is from this cause a gain in direct tensile strength, to which must be added an increase of strength in the iron between the holes. These are together equal to about 12 per cent.

2. The strength of an iron deck under *compression* is limited, not by the area of section, but by its resistance to buckling between the beams. According to the ordinary mode this is very small, since it is quite free to bend downwards between the beams. But by spacing the deck fastening, as shown, at intervals of about 2 feet instead of 3 feet 6 inches, the tendency to buckling would be reduced. The wooden deck would thus, both by its own direct resistance to compression, and by the support it gives to the plates, play a most useful part in compression, although it is powerless as against extension when in connexion with iron. I therefore conclude that no loss of compressive strength is incurred by the holes in the plates.

3. All the holes for receiving the deck fastening may be punched; whereas, if the fastening is in the beam-flanges, the holes for them must be drilled either in the plates or in the beams.

4. The expense of cutting, fitting, punching, and riveting butt straps is avoided. Where the material employed is steel, the gain is more considerable, as all the holes in the butts of the plates and in the straps have to be drilled to prevent the injury done by punching.

5. The weight of material admitted at the butts amounts to one-seventh of the whole material employed.

6. There is a gain in strength against injury and rupture by the action

of sudden forces, the amount of which is not susceptible of calculation, but which, being in proportion to the extent of the spaces of uniform strength which have been introduced, is, I think, very considerable.

The novelty of this proposal may be said to consist in so arranging the iron or other metal plates forming the flanges of girders, bridges, and other structures, or employed in decks, partial decks, stringers, or ties in a ship or vessel, as to make the tensile strength of the unperforated plates, intervening between adjacent butts, equal or nearly equal to the strength of the said intervening plates taken together with that of one of the butted plates where they are perforated, *i. e.*, across the row of holes made for the purpose of attaching the plates to the beams, angle irons, stiffeners, or other iron framing, and by this means rendering the use of butt straps in such combinations unnecessary. In other words, a section through the plates between the beams or stiffeners is made to have, without butt straps, about the same tensile strength as a section through the fastening at the beams or stiffeners, for the purpose of forming spaces of uniform tensile strength not greater than that of the weakest place in the combination. In these intervals elongation will take place (to an extent depending on their length) before the materials can be ruptured, so that an increased amount of work will require to be done by the operation of a given strain in producing rupture. Also, in increasing the resistance to rupture under sudden strains in single plates, by reducing the tensile strength throughout certain intervals between the beams, angle irons, or stiffeners, and approximating to that at the beams, angle irons, or stiffeners, by cutting out portions of the plate.

I am aware that iron decks are not used in merchant vessels, although they are in all iron war ships built for the Admiralty, and I consider it to be false economy to substitute for such decks or partial decks stringers on the ends of the beams, tie-plates near their middle, and diagonal braces between them, as I think it clear that, from the round up of the beams, and other causes, a considerable portion of this material is unable to succor the rest when the top of the ship is put in tension or compression. The strength of wrought iron in extension and in compression is about the same, yet the bottom of the ship is usually made enormously stronger than the top. Some iron ships, indeed, have no proper top, or only a wooden one. Much of the strength of the bottom, which might otherwise be made available in giving strength to the ship, considered as a floating girder, is thus wasted.

I hope that the economical considerations pointed out may be not only useful in lightening and strengthening ships designed for war, but in inducing private ship-builders to introduce partial iron decks, so formed, into ships designed for commerce. These proposals do not form the subject of any patent.

Recent Improvements in the Application of Concrete to Fire-proof Construction. By Mr. J. Ingle.

Read at the British Association, Nottingham, 1866.

From the London Civ. Eng. and Architects' Journal, October, 1866.

Amongst the various methods of fire-proof construction as applied to the floors, ceilings, and roofs of buildings, which have been in use within the last twenty or thirty years, those in which concrete forms the fire-resisting medium have been most frequently adopted. The main reason for this preference, no doubt, is that the horizontal form in which it is generally disposed suits best the requirements of modern construction.

Brick arches, though used almost without exception to carry the floors of the large fire-proof mills and warehouses of the manufacturing districts, have disadvantages which almost preclude their use in buildings of a more general or domestic character. They require walls and girders of great strength to sustain their weight and to withstand the outward thrust which they exert, and the depth which they occupy on account of their rise, when added to the board and joist arrangement above and the ceiling underneath, is so great as to involve a considerable increase of height in the building to obtain the same clear space between the floors and ceilings of the rooms. Of the systems of fire-proofing in which concrete forms the chief element, that of Messrs. Fox and Barrett is the one which has been most extensively used.

It consists of a series of light rolled iron joists fixed 2 feet apart, upon the lower flanges of which are placed fillets of wood at intervals of an inch or an inch and a half. Upon these a mass of concrete is thrown, the depth of the same being regulated to some extent by that of the iron joists, the concrete being generally brought up flush with their upper flanges.

The whole is then paved, or covered with an ordinary wood floor upon light sleeper joists. The underside of the floor receives a second series of wood fillets nailed transversely to the first, and at intervals of 12 or 15 inches, and upon these the ceiling is then formed in the ordinary manner.

The concrete used in this construction, in common with all others in which ordinary lime forms an ingredient, is not, strictly speaking, a fire-proof body. The cementing material which occupies the interstices between the fragments of stone or gravel becomes, like ordinary mortar, in setting, a weak carbonate of lime, and like the stone, from which it was originally burnt, is reduced by calcination to a state of lime. This effect would undoubtedly be produced upon any lime concrete which formed part of the construction of a floor exposed to a severe conflagration.

The application of water to lime in the caustic state converts it, of course, to a hydrate; and while undergoing this change it assumes double its original bulk and falls to powder. The consequences, therefore, which might naturally be expected to ensue from the play of water from the fireman's hose upon concrete floors in a calcined state, would be the

overthrow or fracture of the outer walls by their expansion. Some of the numerous instances of the destruction by fire of buildings, which were supposed to be secure from that danger, are probably owing to this circumstance.

I have more especially alluded to this radical defect of ordinary concrete as a fire-proof medium, because, in the system which I am about to describe, a kind of concrete is employed which retains its cohesion and a considerable portion of its original strength, though water be thrown upon it while in a red-hot state.

This method is a local invention, and is known as "Dennett's fire-proof construction." I shall speak first of the composition of the concrete, and then proceed to describe the manner in which it is applied.

Gypsum, known chemically as sulphate of lime, and which is one of the most perfect non-conductors of heat, is the most important constituent of the concrete, and is used in lieu of the ordinary lime as its cementing material. This gypsum, however, unlike that manufactured into the plaster of Paris which is used for ornamental purposes, undergoes a thorough calcination. The latter is simply roasted in ovens, the finer lumps of gypsum being carefully selected for the purpose. The effect of this roasting is merely to drive off so much of the water which enters into its chemical composition as to allow the gypsum to be ground by millstones.

The rapidity of setting, which is peculiar to this kind of plaster, is owing to the fact of its having but little water to take up in order to resume a state of consolidation.

For the manufacture of the plaster used in Dennett's concrete the coarser qualities of gypsum are used, such as, in fact, except for this purpose, would be thrown aside as mere waste. These inferior qualities are largely impregnated with clay, with the beds of which it alternates, and this clay when burnt becomes the very kind of material which is afterwards added artifically in the mixing up of concrete.

For this purpose any hard material possessing a high degree of porosity is used, such as furnace crosses, oolitic stone, or broken brick. The latter, being in most cases readily procurable, is generally used. It is necessary that all dirt and dust should be carefully screened out, so as to prevent the choaking of the pores of the brick.

The sizes of the lumps are graduated so that the smaller ones shall fill up the interstices of the larger. By this means, and by considerable force used in consolidating the concrete, it is made to consist of a large proportion of the hard material, and its strength is much increased by the proper observance of these precautions.

Some considerable time is occupied by the concrete in setting, as a great amount of water is required to be taken up by the plaster on account of its thorough calcination.

When the setting process is complete a degree of hardness is attained, however, to which that of ordinary plaster of Paris will bear no comparison, and which is equal to that of the best cements.

The form in which the concrete is generally applied to the construc-

tion of floors is that of an arch, or series of arches, with small rise. These are formed upon temporary centres, which may be removed after an interval varying from two to six days, according to the state of the atmosphere and the size of the arches.

Spans of from 6 feet to 12 feet can be bridged over in this manner, the thickness of the arch varying from 3 inches to 5 inches in the crown, and from 5 inches to 10 inches in the haunches. Rolled or riveted iron girders form the intermediate supports of the arches, while the outer haunches rest upon projections or corbel courses in the brickwork. Floors of corridors and cottage rooms can be formed, however, without the aid of any joists or girders whatever. Of course, the arch-form presupposes a certain amount of support from the abutments, but from the transverse strength and thoroughly homogeneous character of the material very little if any lateral thrust is exerted on the outer walls.

If a wood floor is required, sleeper-plates and light joists and boards are laid in the ordinary way; but if there is no necessity for this kind of finish, or if it is desirable to make the upper surface fire-proof, the haunches of the arches may be filled up to a horizontal line and paved with stone, tiles, cement, or asphalte, as may be desired.

The cheapest and best kind of paving, however, is that which may be formed by the concrete itself. To do this the porous material is graduated in size until the surface can be finished with the trowel. This surface can be executed in various tints, and with different degrees of polish.

For bed-room floors this method of finish is particularly adapted; it is cleanly, non-absorbent, free from vibration, and therefore comparatively noiseless; and, what is a very important consideration, particularly in the crowded districts of large towns, affords no harbor for vermin. Any objection which might exist against these floors on the score of coldness may be removed by placing a sheet of hair, felt, or matting of cocoa fibre under the carpet.

Floors of coarse plaster laid upon reeds or laths on the ordinary joists were formerly very common, and are still used to some extent in Nottingham and other towns of the Midland district; and it is no doubt owing to this circumstance that the destruction of a dwelling-house by fire is here a matter of very rare occurrence indeed.

The mode of finishing the underside of these floors depends upon the character and architectural requirements of the building. For banks, offices, hospitals, and many other public buildings, there is often no objection to the curved surface which the soffits of the arches present, and which are, moreover, well adapted to receive colored decoration. Where, in buildings of a more domestic character, a flat ceiling is indispensable, a series of light joists to receive the ordinary lathing is affixed to the lower flanges of the girders. As these form no part of the main construction of the floor, their destruction in case of fire would not impair the stability of the arch, which forms the fire-proof medium.

With regard to the strength of the concrete, very severe tests were applied to some of these arches at the new town hall at Hackney, under

the direction of the district surveyor, and with very satisfactory results. These experiments were tried with reference to their capacity for sustaining dead pressure, and also with regard to their resistance to impact. In the latter case a rough block of stone weighing 250 lbs. was dropped from a height of 14 feet upon the centre of an arch which was but $3\frac{1}{2}$ inches thick in the crown, and bruised but did not break it; while another block, weighing 750 lbs., let fall from a similar height upon an adjoining arch, went through with a clean fracture, causing no disturbance of the general construction.

Some further ideas of the strength and capabilities of the material may be formed when it is stated that vaults and domes have been executed therein at the new Foreign Offices, of spans varying from 10 feet to 36 feet. The vault of the latter dimension is semicircular on the section, and the concrete is 9 inches in thickness, with occasional ribs and groins to the side windows.

Mr. G. G. Scott, who first adopted this method of construction seven years ago for the thorough fire-proofing of Kelham Hall, near Newark, the seat of Manners Sutton, Esq., speaks of it in the following terms:

"I have made use of Messrs. Dennett's material for fire-proof arching, and though I have happily had no practical experience of its efficiency as against fire, I can bear witness to its strength and its extreme convenience of application. I have made use of it in positions in which I should have found it difficult to introduce any other fire-proof material, and it has this advantage, that the arches constructed of it are so entirely in one mass that they cover the space like a compact shell or inverted basin, and are, consequently, almost wholly free from lateral pressure."

The cost varies, of course, with the distance of the place where the system is adopted from the localities where the gypsum is quarried; but in most parts of the country it is found to be cheaper than any other method of fire-proofing, while in the immediate neighborhood cottage floors can be formed at a cost less than that of ordinary wood construction.

Cantor Lectures.—On Submarine Telegraphy. By Fleeming Jenkin, Esq., C.E., F.R.S.

From the London Journal of the Society of Arts, No. 691.

LECTURE III.

(Continued from page 310.)

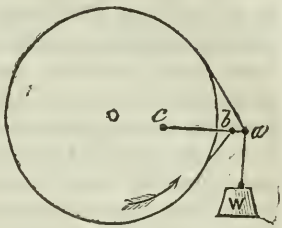
Laying and Repairing Cables.—The lecturer mentioned that he had received a letter from Messrs. Wells and Hall, stating that some lengths of their india rubber cables had been at work for some time under water. This was not doubted, but did not affect the original statement, that much india rubber had decayed, whereas no gutta-percha under water had decayed. Mr. Hooper had also misunderstood the statement in the abstract, that pure india rubber yielded to continued pressure. This was not meant to apply to Mr. Hooper's material, which is always more or

less vulcanized. Attention was also drawn to a map of the telegraph lines between Europe and the East, prepared by Messrs. Bright & Clark, and kindly lent by them. The following is an abstract of the lecture arranged under the heads of the syllabus:

1. *Stowage on Board Ship.*—The cable is coiled into large circular, or nearly circular, coils, so as to uncoil without receiving a twist, as shown on the last occasion. The coils are now held in iron water-tight tanks, and remain constantly under water. Tanks were first made for the Red Sea cable, but first used for the Malta-Alexandria cable. The tanks in the *Great Eastern* were three in number, from 51 feet 6 inches to 58 feet 6 inches diameter, and 20 feet 6 inches deep. To prevent rolling, their centre of gravity should be only slightly below the water-line. If the water be withdrawn from the tanks before the cable is paid out, the wires rust, and the chemical action heats them injuriously. With galvanized wires or cables covered with Bright & Clark's composition this heating does not occur. The eye of the coil round which the cable lies, generally from 6 to 8 feet in diameter, is filled with a cylinder, to prevent the bight of the cable from falling down, and possibly forming a kink or loop. Mr. Newall uses a cone permanently fixed in the centre of the coil. Messrs. Glass & Elliott lower their solid eye as the uncoiling proceeds. The cone appears to the lecturer to afford the best guarantee against kinking. It was used in the Persian Gulf expedition. When running out at high speeds, the cable, if unchecked, would fly out, urged by centrifugal force, so as to be dangerous and unmanageable. This tendency is controlled by rings, lowered as the tanks are emptied, and first forcing the cable to run horizontally towards the centre and then controlling its upward motion. These rings were first used by Messrs. Newall & Co.

2. *Break.*—From the tanks the cable is laid in troughs to the break, by which a restraining force is applied to prevent too rapid egress. The troughs in the *Great Eastern*, from the fore-hold to the break, measured 450 feet. The cable is wound four or five times round a drum 6 or 8 feet in diameter, and the rotation of this drum is controlled by friction. The turns round the drum hold the cable securely, and prevent its egress unless the drum itself turns. The riding of the cable is prevented by a simple contrivance known as a knife or plough, which was exhibited on a model. On the *Great Eastern* this knife or plough could be adjusted. The simplest manner of applying retarding friction to the break is to hang a weight on to a break strap, the other end of which is fixed. If the weight is hung from that end of the strap which would be lifted by the friction of the drum as it revolves, the retarding force can never exceed the weight, and a limit may be thus placed to the strain on the cable. But it was found in practice that, with a strap making less than one turn round the drum, a weight of say four tons had to be applied to give a friction of one ton. The limit due to the position of the weight was, in such a case, of small value, since any heating of the strap or dirt on its surface might rapidly increase the strain four-fold. Mr. Appold's break remedies this defect. The prin-

ciple on which it is constructed is illustrated by the annexed diagram. The end of the strap *a*, on which the greatest strain comes, is attached to a lever hinged at *c*. Between the centre of the drum and *a*, the other end is attached to the lever very near *a;* but between *a* and *c* the retarding friction is obviously equal to the difference of the strains on the end *a* and *b* of the break-strap, and the weight *w* is almost exactly equal to that difference. This relation does not depend on the co-efficient of friction between the strap and the drum. If the friction increases, the weight *w* is raised a little, and the lever *a c*, owing to the eccentrical position of *c*, slightly lengthens the break-strap, reducing the friction. The opposite effect occurs if the co-efficient of friction diminishes. The motion of *c a*, required to tighten or lossen the break-strap, is almost infinitely small, so that the angles of the break-strap and lever, and the relations of the strains, do not sensibly vary. This arrangement was used on the *Great Eastern.* It worked admirably, and gives a perfect safeguard against the application of any unforeseen strain by the friction of the break-strap. Strains may, however, occur from other causes, and for their detection a dynamometer is used between the break and the stern. The cable is passed under a weighted pulley, at a somewhat obtuse angle. The weight thus hanging on the cable is raised higher and higher as the strain on the cable increases. A scale is constructed by experiment showing the height corresponding to each strain. By this simple contrivance the actual strain on the cable can be observed at any moment. The following is a convenient formula for calculating the relation between the strains on break-straps and the friction produced. Let Q be the strain on that end of the strap which holds back the wheel, P the strain on the other end, *f* co-efficient of friction, and *b* the angle embraced by the strap in circular measurement, (unit $=57{\cdot}296^\circ$.)



Then, $Q=e^{fb}\,P$, where $e=2{\cdot}71828$.

f may be taken for	leather on iron,	. .	$=0{\cdot}35$
" "	iron on iron, wet,	. .	$=0{\cdot}15$
" "	wood on iron, wet, less than		$0{\cdot}1$

3. *Theory of Submersion.*—In October, 1857, Professor William Thomson published in the *Engineer* a short sketch of the true mathematical theory of the form assumed by a cable while sinking, and the strains to which it is subjected under various conditions. The consequences of this theory were much more elaborately worked out (independently of Professor Thomson's publication, the lecturer believes) by Messrs. Brook & Longridge, in a paper read before the Institution of Civil Engineers, in the spring of 1858. Much of what follows is taken from that paper. If the ship and cable are both at rest in still water, the latter hangs in a catenary curve, the strains on which are known and easily computed. This case actually occurs whenever a ship stops paying out cable, for instance, to cut out a fault. If the cable were

suddenly stopped, so as to lie at a great angle with the vertical line, a strain would be produced so great as infallibly to break the cable. Thus, for a catenary in which the cable at the point of suspension lies at an angle of 9° 30′ with the horizon, the strain at the point of suspension is equal to $72\frac{1}{2}$ times the weight of the cable hanging to the same depth vertically; so that in 2000 fathoms the strain would be equal to the weight of 145 miles of cable; but the Atlantic cable would break as soon as the strain exceeded the weight of 11 miles. From this it will be seen that a cable cannot be immediately stopped whilst being paid out, but must be gradually checked while the ship is backed, so as to keep the cable where entering the water as nearly vertical as possible. Another conclusion which follows is, that the cable while being paid out cannot possibly be hanging in a catenary curve; since the Atlantic cable did lie at an angle of about 9° 30′, and the strain, instead of being 2030 cwt., was only about 12 cwt. The following consideration may help us to perceive how different the case of a body sinking regularly is from the case of a chain at rest. Suppose the ship to drop a number of spheres of the specific gravity of the cable into the water at regular intervals; each of these would, within about two feet of the surface, acquire a definite sensibly constant velocity $v = \sqrt{\frac{w}{q}}$ where w = the weight, and q the resistance to the body moving at one foot per second. These spheres, moving with constant velocity at constant intervals of time, would lie in a straight line from the surface to the bottom, and would be more or less inclined to the horizon as the speed of the ship was less or greater. If the spheres were joined by an infinitely thin string, to which the water offered no resistance, they would form a cable which could be laid without any tension whatever, and with an amount of slack or waste depending simply on the inclination of the line to the horizon. The practical case of a submarine cable lies between these two extremes of the catenary and the isolated spheres; each short length of the cable lies like an inclined rod in the water, and has, therefore, a tendency to shoot back in a given direction, whereas the isolated spheres tend to fall vertically. Owing to this, cables, or at least heavy cables, cannot be laid without tension, except at the expense of an enormous waste of cable. It will be unnecessary here to repeat the whole mathematical investigation which is given in Messrs. Brook & Longridge's paper. It will be sufficient to give the results arrived at. Mathematical readers will readily understand that these results are calculable from the data given:

v = the velocity of the paying out vessel in feet per second.
v_1 = the velocity of the cable paid out in feet per second.
w = the weight of one foot length of the cable in pounds.
φ = the angle which the cable at the surface makes with a horizontal line.
x = the height of any point A from the bottom of the sea.
q = the resistance in pounds which the water opposes to the motion of each foot of the cable moving perpendicularly to itself,

speed of one foot per second; q may be called the co-efficient of resistance to displacement.

q_1 = the resistance in pounds which the water opposes to the motion of each foot of the cable drawn through it lengthwise at the speed of one foot per second; q_1 may be called the co-efficient of friction.

m = the resistance in pounds which the water opposes to the motion of each foot of the cable moving perpendicularly to itself, at the speed of v feet per second; m is assumed $= q\,v^2$.

m_1 = the resistance in pounds which the water opposes to the motion of each foot of the cable drawn through it lengthwise at the speed v; m_1 is assumed $= q_1\,v^2$.

t = tension in pounds at point A, which in what follows will be assumed as at the surface where the maximum strain occurs.

Then, if the cable be laid without any tension at the bottom, which is now invariably done, the equation to the curve assumed by the cable will become the equation to a straight line inclined at an angle to the horizon such that

$$(1.)\ \text{Cos. } \varphi = \frac{\sqrt{w^2+4m^2}-w}{2m},$$

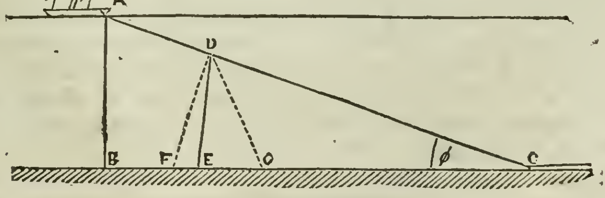
or, what amounts to the same,

$$(2.)\ \frac{\text{cos. } \varphi}{\text{sin.}^2\ \varphi} = \frac{q\,v^2}{w.}.$$

From this it appears that the angle at which any given cable will be paid out is (when not tight at bottom) independent of the tension t, (or of the velocity v_1,) and is dependent simply on the velocity v of the ship. Cables which are bulky for their weight, or, in other words, are of light specific gravity, lie at a small angle; but, by increasing the ship's speed, any cable may be paid out at a small angle. We find further, when no slack is paid out,

$$(3.)\ t = \left(w - m^1 \frac{(1-\text{cos. } \phi)^2}{\text{sin. } \phi}\right) x.$$

wx is simply the weight of the length of the cable hanging plumb from the ship to the bottom. This is the maximum tension that can be required to lay any cable without slack. This tension is always slightly



diminished by a certain small portion of its amount constant for a given speed and cable. The annexed diagram may help to explain the

results arrived at. The cable A C, lying on an inclined plane of water at the angle ϕ, is carried by a tension equal to the weight of a length A B of cable, somewhat as a chain would be in equilibrium lying on a frictionless inclined plane A C, and hanging down over a pulley at A to the depth B; but the inclined plane of water is not at rest. It yields under the cable at every instant at every spot; if the cable were pressed through the water in a direction perpendicular to itself, so that the plane of water yielded before the pressure of the cable, and did not slip along it at all, the above analogy would be perfect, and the tension at A would be simply equal to $w\,x$; but since we have supposed the cable to be laid without tension, and without slack at the bottom, any point D must finally come to a point E, such that E C = D C, and it will be easily seen that the point D to do this must move in a straight line E D. Now, this line D E is not perpendicular to A C; it falls within that perpendicular D F, so that if we suppose the plane of water under A C to yield perpendicularly before it, we must also conceive the cable as slipping back a little on the plane by an amount corresponding to the space between D F and D E; but this slip is opposed by the friction of the water, which thus tends to prevent the cable from running back on the inclined plane, and so relieves the tension by a small amount. This amount is so small that it may be practically neglected, and would not have been mentioned did not the same considerations enable us to understand the effect of laying cable with a certain amount of slack. When this is done, a point D moves in a line, say D G, differing much more in direction from D F than D E does. When much slack is laid, the cable slips back at a considerable velocity on the inclined plane, and meets with a frictional resistance tending considerably to relieve the tension. Thus, when the cable is paid out at a velocity v_1, we have

$$(4.)\quad t = \left\{ w - m^1 \frac{\left(\frac{v^1}{v}\cos.\phi\right)^2}{\sin.\phi} \right\} x.$$

When v_1 is considerably in excess of v, the fraction of the whole tension which the friction m^1 subtracts from $w\,x$ is very considerable. It also increases rapidly as the speed of the ship increases, and it further increases if the specific gravity of the cable be small, for then it lies at great length in the water, presenting an immense surface to be gripped by the water. The friction on each foot is but small, but when twelve or thirteen miles of cable lie in the water, presenting a surface of 70,000 or 80,000 square feet, the result is practically very important. Assuming a mean speed of 10·4 feet per second as that at which the Atlantic cable was paid out when lying at an angle of 9° 30′ in 2000 fathoms of water, with a tension of 12 cwt., we obtain the following values for the constants:

$$\left.\begin{array}{l} q = 0\ 085 = 0{\cdot}81\ \text{D} \\ q_1 = 0\ 0085 = 0{\cdot}001\ \text{D} \end{array}\right\} \text{ where D = diameter of cable in feet.}$$

From some observations, it would seem as if the angle had been even

less than the above, in which case q would be larger and q_1 smaller. From Beaufoy's experiments we should have expected q to be more nearly 0·65 D; but the roughness of the cable may account for the difference, as it certainly does for the great difference in the co-efficient of friction, which is nearly eight times that which a smooth surface would present. It is probable that, for a smooth iron cable, the value of q_1 would be more nearly equal to 0·001 D, and $q = 0·065$ D. One reason will now be plain for giving in the foregoing tables the strength of the various cables relatively to the depth in which they are to be laid. The strain required to lay them is always a fraction of that depth, but the strain will not be always the same fraction of the depth, but will be smaller for the lighter cables when laid slack.

4. *Application of Theory.*—The practical results of equation (4) are most important. To lay any cable, however light, quite taut, we require nearly the tension due to a weight of the cable hanging plumb from the surface to the bottom; but by increasing the bulk of any cable, though we do not diminish its actual weight, we may, by laying a little slack, diminish the tension very greatly. With such a cable as the second Atlantic the tension was thus diminished more than half; to lay it taut would have required nearly 28 cwt., and 12 cwt. was the amount actually required when about 15 per cent. slack was paid out. The strain could be maintained constant in all depths, by allowing a little more slack to run out in deep water, and even this could be prevented by a slight increase in the speed of the ship. No relief at all, comparable to the above, is obtained by paying out heavy cables slack; but, on the other hand, still lighter cables can be paid out under still more favorable conditions. The rattan and hemp cable (No. 11, Appendix 1) would, with 12 per cent. slack, be paid out without any strain at all, and if more slack than this were desired, the cable would have to be pushed out of the ship. Nearly the same might be said of a bare gutta-percha wire. The Atlantic cable, in the last expedition, was laid in depths varying from 1750 to 2000 fathoms, at speeds for the ship varying from $4\frac{3}{4}$ to $6\frac{3}{4}$ knots per hour, while the cable ran out at from 5 to nearly 8 knots per hour. The angle, according to one method of observation, varied from 9° to nearly 12°, but was somewhat less according to other observations; 9° 30′ seems to have been a usual angle. The slack paid out in deep water ranged from 9 per cent. to about $18\frac{1}{2}$ per cent. On the last day the slack was about 14·8 per cent. The strain on the cable was very constant, ranging from 10 cwt. to 14 cwt., and generally being between 11 cwt. and 13 cwt. The pitching of the ship never caused more than about 2 cwt. difference in the strain; but once, when going slow to change holds, the strain was 17 cwt.: this accords with theory. The lecturer has to thank the engineers of the Telegraph Construction and Maintenance Company for the above information.

(To be continued.)

Theory of the Influence of Friction upon the Mechanical Efficiency of Steam. By W. J. MACQUORN RANKINE, C.E., LL.D.

Paper read before the British Association, Nottingham, 1866.

From the London Civ. Eng. and Architect's Journal, October 1, 1866.

1. Attention has been called to the fact that the heat produced by the friction of the piston, piston-rods, and trunks of steam engines must be wholly or partly communicated to the steam, and must thus affect the work of the steam and the expenditure of the heat upon it. The object of the present paper is to point out how that fact, when treated according to the principles of thermodynamics, affected the efficiency of steam.

2. The most general and elementary way of considering the subject is as follows: Let W denote the whole indicated work of the steam in a given time, including that which is lost through friction in the cylinder; let F be the part of that work which is so lost, so that W—F is the available work; also let H be the whole expenditure of heat upon the steam in the same time, expressed in units of work by the aid of the first law of thermodynamics. Then $\frac{W}{H}$ is the efficiency of the steam when friction is not taken into account. If we take into account the loss of work through friction, but not the gain of heat, the efficiency is reduced to $\frac{W-F}{H}$. With respect to the gain of heat through friction, it is to be observed that, if the cylinder is properly jacketed and protected, the whole of the heat due to the friction of the piston must be communicated to the steam, and that, if we consider the great superiority of slightly moist steam above air in conducting power, it is probable that a small fraction only of the heat due to the friction of piston-rods and trunks escapes without being taken up by the steam also. If, then, we suppose that, sensibly, the whole due to friction in the cylinder is taken up by the steam, there is a corresponding saving in the expenditure of heat, and the efficiency of the steam becomes

$$\frac{W-F}{H-F}, \qquad \ldots \ldots \ldots \qquad (A,)$$

being less than $\frac{W}{F}$, the efficiency neglecting friction; but greater than $\frac{W-F}{H}$, the efficiency when the loss of work is taken into account, but not the saving of heat.

3. For example, let the case be taken of an engine in which the steam is admitted to the cylinder at an absolute pressure of 40 lbs. on the square inch, being 25·3 lbs. on the square inch above the atmosphere, the back pressure being 4 lbs. on the square inch, and the rate of expansion 5 lbs.: the efficiency of the steam in such an engine, neglecting friction, is about $0{\cdot}12 = \frac{W}{H}$. Suppose, now, that one-tenth of the indi-

cated work is lost in friction in the cylinder, and that all the heat of friction is taken up by the steam; that is to say, let $F = 0{\cdot}1\ W = 0{\cdot}012\ H$: then the fraction 0·012 expresses the saving of heat through friction, and the efficiency is found by equation A to have the following value:

$$\frac{W - F}{H - F} = \frac{0{\cdot}12 - 0{\cdot}012}{1{\cdot}000 - 0{\cdot}012} = \frac{0{\cdot}108}{0{\cdot}988} = 0{\cdot}1093.$$

The result of taking into account the loss of work, but neglecting the saving of heat, is $\frac{W - F}{H} = 0{\cdot}108$.

4. The following is the result of applying the principles of thermodynamics more in detail to the process of expansive working as affected by friction. During any small portion of the process of expansive working, let $d\,W$ be the total work done, including friction, and $d\,F$ the part of that work which is lost in friction; also let t be the absolute temperature at which the work $d\,W$ is done, and k the real dynamical specific heat of the substance: then, by the second law of thermodynamics, the expenditure of heat during the given small portion of the process is $d\,H = t\,d\phi$; in which the "thermodynamic function" ϕ has the following value:

If all the heat due to the friction is taken up by the working substance, let $d\,H^1$ be the diminished expenditure of heat; then the thermodynamic equation of the process becomes

$$d\,H^1 = d\,H - d\,F = t\,d\phi - d\,F, \qquad \text{(B.)}$$

And if, as is often sensibly the case, the work done in friction is a constant fraction of f of the whole work, so that $d\,F = f\,d\,W$, we have the following equation:

$$d\,H^1 = t\,d\phi - f\,d\,W, \qquad \text{(C.)}$$

5. The special mode of operation of friction in saving heat during the working of steam in ordinary steam engines probably consists in a diminution of the additional supply of heat required by the steam while in the cylinder, in order to prevent the accumulation of liquid water there. It is known that during the expansive working of steam heat disappears: that part of such disappearance of heat (viz: from one-fourth to one-fifth of it) takes effect in lowering the temperature of the steam to that corresponding to the diminished pressure, and that the remainder (being from three-fourths to four-fifths) tends to produce liquefaction of part of the steam. Such liquefaction is known to cause, indirectly, great waste of heat, through the distillation of the liquid water into the condenser, and consequent abstraction from the cylinder of heat, which has to be supplied by means of an increased expenditure of boiler steam. In order to realize, therefore, the economy due to expansive working, it is necessary to keep the steam, during the expansion, nearly in a state of dryness; and for that purpose it must be supplied with heat to the extent of from three-fourths to four-fifths of the heat which disappears during the expansion. That supply of heat may be conveyed from the boiler either by means of a steam-jacket, or of superheating, or by both

methods combined; and the heat due to friction in the cylinder, by contributing to that supply, diminishes the part of it which it is necessary to obtain from the boiler.

6. The theoretical formulas for the indicated work, and the expenditure of heat in a steam engine working with dry saturated steam, are as follows:*

Let the initial absolute temperature, absolute pressure, and volume of one pound of steam be denoted, during the admission into the cylinder, by t_1, p_1, and v_1, and at the end of the expansion by t_2, p_2, and v_2; so that $\frac{v_2}{v_1}$ is the rate of expansion.

Let p_3 be the back pressure of the exhaust steam in the cylinder, and t_4 the absolute temperature of the feed-water.

Let $a - bt$ be the approximate value, in units of work, of the latent heat of evaporation of one pound of water at the absolute temperature t, the constants being as follows:

$a = 1109550$ foot-pounds;

$b = 540{\cdot}4$ foot-pounds per degree of Fahrenheit, or $972{\cdot}72$ foot-pounds per Centigrade degree.

Let J be Joule's equivalent of the specific heat of liquid water = 772 foot-pounds for Fahrenheit's scale, or 1390 foot-pounds for the Centigrade scale, nearly.

Let U denote the work done by a pound of steam, on the supposition that the back pressure is equal to the final pressure ($p_3 = p_2$), and W the whole indicated work done by a pound of steam.

Then $$\mathrm{U} = a \text{ hyp. log. } \frac{t_1}{t_2} - b\,(t_1 - t_2), \quad . \quad . \quad . \quad (\mathrm{D},)$$

and $$\mathrm{W} = \mathrm{U} + (p_2 - p_3)\,v_2, \quad . \quad . \quad . \quad . \quad . \quad (\mathrm{E};)$$

also the expenditure of heat per pound of steam is

$$\mathrm{H} = \mathrm{U} + a - b\,t_2 + \mathrm{J}\,(t_2 - t_4), \quad . \quad . \quad . \quad (\mathrm{F}.)$$

Now the total heat of evaporation of one pound of steam, at the initial temperature t_1, is $\mathrm{H}_1 = a - b\,t_1 + \mathrm{J}\,(t_1 - t_4)$, ... (G,) and the difference between this and the total expenditure of heat is the additional heat which must be supplied to each pound of steam in order to prevent liquefaction in the cylinder, that is to say,

$$\mathrm{H} - \mathrm{H}_1 = \mathrm{U}\ (\mathrm{J} - b)\ (t_1 - t_2)$$

$$= a \text{ hyp. log. } \frac{t_1}{t_2} - \mathrm{J}\,(t_1 - t_2), \quad . \quad . \quad . \quad (\mathrm{H}.)$$

It appears, by calculating numerical results in particular cases, that

$$\mathrm{H} - \mathrm{H}_1 = \text{from } 0{\cdot}75 \text{ to } 0{\cdot}8\ \mathrm{U}, \text{ nearly}, \quad . \quad . \quad (\mathrm{K},)$$

$0{\cdot}75$ being the co-efficient at high temperature, and $0{\cdot}8$ at low.

7. It is out of this latter part of the expenditure of heat $\mathrm{H} - \mathrm{H}_1$ that the saving is made through the heat produced by the friction in the

* For their demonstration see "Phil. Trans.," 1859, and "A Manual of the Steam Engine and other Prime Movers," p. 396; and for approximate formulas for practical use, see also "The Engineer," Jan. 5, 1866, p. 1, and "Useful Rules and Tables," p. 282.

cylinder. The following are four examples of the theoretical calculation of the work and expenditure of heat per pound of steam, and of the efficiency, with and without allowances for friction:

No. of Example.	I.	II.	III.	IV.
Temperature—Fahrenheit.				
Initial, ordinary	338 deg.	338 deg.	257 deg.	257 deg.
" absolute, $t_1 =$	799 "	799 "	718 "	718 "
Final, ordinary	248 "	203 "	176 "	221 "
" absolute, $t_2 =$	709 "	664 "	637 "	612 "
Feed-water, ordinary	104 "	104 "	104 "	104 "
" absolute, $t_4 =$	565 "	565 "	565 "	565 "
Pressures—lb. on the square foot—				
Initial, $p_1 =$	16580	16580	4854	4854
Final, $p_2 =$	4152	1765	980	2524
Back, $p_3 =$	649	649	649	649
Volumes—cubic feet to the lb.—				
Initial, $v_1 =$	3·814	3·814	12·09	12·09
Final, $v_2 =$	14·00	31·26	53·92	22·34
Rates of expansion $\frac{v_2}{v_1} =$	3·67	8·2	4·46	1·86
Indicated work in foot-pounds per pound of steam, at pressures above the final pressure, $U =$	83930	132350	89000	37600
Do. at pressures below the final pressure $(p_2 - p_3)\, v_2 =$	49042	34700	18140	41900
Total indicated work, foot-pounds, per lb. of steam, $W =$	132972	167050	107140	79500
Heat expended in foot-pounds per lb. of steam, before admission, $H_1 =$	859175	859175	740139	840139
Additional heat to prevent liquefaction (without deduction) $H - H_1 =$	62778	100623	69964	29139
Total heat expended (without deduction) $H =$	921953	959[illegible]3	910103	860278
Efficiency without friction $\frac{W}{H} =$	0·1442	0·174	0·1176	0·0915
Suppose co-efficient of friction one-tenth, then work lost in friction and heat saved $F = \frac{W}{10} =$	13297	16705	10714	7950
Available work $W - F =$	119675	150345	96426	71559
Heat expended to prevent liquefaction, deducting that saved by friction, $H - H_1 - F =$	49481	83918	59250	2118
Total heat expended, deducting that saved by fricton $H - F =$	908656	943093	899389	861328
Efficiency, allowing for friction $\frac{W - F}{H - F} =$	0·132	0·1595	0·1073	0·083

8. From the preceding formulas and calculations it appears, that although the heat produced by friction in the cylinder makes but a trifling saving when compared with the whole heat expended, it may become considerable when compared with that part of the expenditure of heat which is employed to prevent liquefaction of steam in the cylinder, and may thus co-operate usefully with the action of jacketing and superheating.

In reply to some observations by Mr. Smith and Mr. Bramwell, the

latter of whom pointed out that the heat generated would be carried away in part by the exhaust, Professor Rankine said he was sorry that he should have explained himself so badly in his original paper as to lead Mr. Bramwell and Mr. Smith to suppose that he regarded the heat generated by friction as increasing the motive power. That was not what he had intended to convey. He was far from supposing that the heat generated by friction added in the slightest degree to the amount of the working power of the steam, or even made the diminution of the work less than it would otherwise be. What he meant to convey was that the effect which he had ascribed to the heat produced by friction was not a gain or saving of mechanical work, but simply a saving of a portion of the heat which would otherwise be lost in preventing liquefaction of the steam. Whatever quantity of heat was produced in the cylinder by friction, precisely to that extent would the heat which it was necessary to supply by means of jacketing or superheating be diminished. Steam must be dried or superheated by wire-drawing, or passing through a small aperture without performing work. Most engineers, however, would agree with him that to dry or superheat steam by that method was not economical, and that the same object could be better attained by the direct application of heat.

The Water-jet Propeller.

From the London Engineering, No. 43.

The data of the recent experimental trip of the *Water-witch*, although not complete, are sufficiently so to show a great waste of power in Mr. Ruthven's system of jet propulsion. It is, indeed, probable, and nearly demonstrable, that of the 750 horse power indicated on Friday less than one-fourth was actually utilized in propelling the ship. The action of the jets admits of very close investigation when the size of the orifices, the velocity of outflow, and what may be termed the velocity of reaction are given. In the case of the *Water-witch*, she is reported to have two jets, each of which, although not circular in form, is equal in area to a circle 2 feet in diameter, the area of both nozzles being 6·28 square feet. If we, for the moment, disregard friction and all deductions whatsoever for losses of any kind, we can easily find what quantity and velocity of sea-water would be maintained through these jets with 750 horse power. Taking sea-water to weigh 64 lbs. per cubic foot, we shall have 15,260 feet, nearly, per minute, discharged with a velocity of about $40\frac{1}{2}$ feet per second, this velocity corresponding to a height of $25\frac{1}{2}$ feet. For to impart to water a motion in any direction, horizontal or vertical, of $40\frac{1}{2}$ feet per second is equal to lifting it to a height of $25\frac{1}{2}$ feet, and to lift 15,260 cubic feet of sea-water per minute to a height of $25\frac{1}{2}$ feet, requires, irrespective of all losses, about 750 indicated horse power. The size of the nozzles being fixed, there is but one quantity of water, and, therefore, but one velocity of discharge, which would exactly work up a given horse power. Knowing, there-

fore, the effluent velocity, we easily find the "head" of water corresponding to, or generating that velocity, and, knowing the head, it is easy to find the pressure within the jet. The presence of a column of sea-water $25\frac{1}{2}$ feet high is $11\frac{3}{4}$ lbs. per square inch, and on the 904 square inches of the two jets this would amount to a total propelling force of 10,245 lbs. The real pressure urging the vessel forward was, as we shall presently see, very considerably less than this, as so far we have made no deductions whatever for loss of effect by friction, &c., either in the engines or water-passages. Resting for a moment with the quantities already obtained, the whole power would be utilized only when the vessel moved forward at the same rate as the effluent velocity of the jets, viz: $40\frac{1}{2}$ feet per second, or 24 knots (of 6076 feet each) per hour. For the power is running away, so to speak, as the cube of the velocity of the jets, while the power utilized can only be as the cube of the velocity of the vessel, the pressure acting to drive the ship being, of course, as the square of the velocity of the jet, thus leaving the proportion of the power utilized to that expended in the simple ratio of the velocity of the ship to that of the jets. For the water-pressure within the passages leading to the jets is necessarily the same ahead and astern, while the work expended in one direction, and that usefully exerted in the other, must necessarily be as this pressure multiplied into the respective rates of motion in a unit of time. Now, the *Water-witch*, so far from moving at the rate of 24 knots per hour, or $40\frac{1}{2}$ feet per second, went at 9 knots an hour, or 15 19 feet per second, and hence, in any case, nearly two-thirds of the power would appear to have been wasted.

But we cannot proceed upon the presumption that no power was lost in the friction of the engine, nor in the large centrifugal pump. nor in the friction of water in the passages, &c. Under all the circumstances, we cannot, as practical men, allow for the work actually done, in ejecting the jets more than one-half that indicated upon the engine pistons. In other words, the weight of water actually delivered would not, when multiplied into the height to which its effluent velocity would carry it, amount to more than one-half of the total number of foot-pounds corresponding to the 750 horse power actually indicated. We doubt even if this allowance for loss is sufficient; for the 14 feet centrifugal pump is one of the very worst form, having nearly radial blades, while the rate of motion to be imparted to the water is very great, and attended, therefore, with great friction. If, however, we throw off one-half only of the indicated power for all losses in the engines, centrifugal pump, and water-passages, the corresponding quantity of water discharged through the two jets would be nearly 12,120 cubic feet per minute, at an effluent velocity of 32 feet per second. This quantity of water, multiplied into the height to which its velocity of discharge would carry it, viz: 16 feet, would correspond very closely to 12,375,000 foot-pounds per minute, or 375 indicated horse power. The size of the jets remaining unaltered, no greater or less quantity could pass, at a greater or less velocity, to correspond to the 375 horse power. Now, a velocity of

32 feet per second, corresponding to a head of 16 feet of sea-water, pressing with a force of 7 lbs. per square inch, ahead and astern, is more than twice the actual rate attained by the vessel, its rate having been 15·19 feet per second. Hence, after first throwing off one-half of the total engine power as lost in friction, &c., we find that more than one-half of the remaining half was lost by reason of the inefficiency of the action of the jets.

Exception may be taken, however, to this mode of calculation, because it does not allow for the diminished co-efficient of discharge, as compared with the discharge theoretically due to a given water-pressure within the jet-pipe. Thus, while the water is actually running out at a velocity of say 32 feet per second, corresponding in theory to a head of 16 feet, and, therefore, to a pressure of 7 lbs. per square inch, the real pressure within the jet-pipe may be much higher, say 9 lbs. or 10 lbs., and thus the driving force upon the ship so much greater. It is here that more complete data are wanting. Thus the pressure as determined by a gauge on the jet-pipe, and the velocity of discharge, if that could be accurately obtained by a velocimeter, would enable us to ascertain exactly the proportion of power utilized. But it will be seen upon reflection that whatever may be deducted for the diminished co-efficient of discharge comes off the "duty" of the pump, and must form a further deduction beyond any we have yet made, although it is compensated by the superior pressure and consequently increased speed of the vessel, as compared with that theoretically due to the actual velocity of the discharge. We can best make this clear by referring back to the case already gone over. We have there made an allowance, founded upon the knowledge and experience of hydraulic engineers,—our own in common with others—for the combined loss from the friction of the engine, friction in pipes, and loss of effect in pump, this allowance being one-half of the total indicated horse power. This includes no allowance for the co-efficient of discharge, as compared with that theoretically due to the pressure in the jet-pipe. Let us, however, now suppose that the actual discharge is but three-fourths that theoretically due to the head. And whether this or any other proportion be taken, we shall find on trial that the final result is the same. The theoretical velocity, after allowing, as we have done, for friction, &c., was 32 feet per second, and three-fourths of this is 24 feet per second, so that the reduced rate of discharge through the two jets would give a delivery of about 9090 cubic feet per minute, and as the effluent velocity is but 24 feet per second, this would carry the water, *in vacuo*, to a height of 9 feet, and is therefore equal to lifting it to that height. But this lift represents but (9090 cubic feet $\times$ 64 lbs. per cubic foot $\times$ 9 feet high) 5,235,840 foot-pounds per minute, and, therefore, but $158\frac{1}{2}$ actual horse power of work expended on the jets, whereas 750 was indicated upon the pistons. The pressure within the jet-pipes, acting to drive the vessel ahead, would still be 7 lbs. per square inch, and, at the speed attained on Friday's trial, this would amount to about 175 horse power actually utilized in propulsion, being still less than

one-fourth that exerted upon the pistons of the engines. And whether, after throwing off the first allowance of one-half for friction, &c., the pump (which we need hardly say is a "turbine," either in its construction or action) gave the full discharge due to the pressure within the jet-pipe, and thus imparted 375 horse power to the jets, or whether it gave a less discharge than that due to the pressure within the jet-pipes, and thus imparted less horse power to the jets, the driving power upon the vessel would be the same in either case, and would amount, in the case of Friday's trial, to but 175 horse power out of more than four times that amonnt of power indicated by the engines.

But we are told the *Water-witch* has gone nine knots an hour, and has done as well as a twin-screw gunboat, of the same size and form, called the *Viper*. We know nothing of the latter vessel, nor is she the *Viper* of 477 tons which appears in the last Admiralty tables of steam trials. If the twin-screw *Viper* has done no better than the *Water-witch*, she is indeed a poor affair, supposing the dimensions, power, &c., to be the same. On her trial last Friday the *Water-witch*, which is a badly shaped vessel, 162 feet long and 32 feet beam, had a mean draft of 9 feet 9 inches, an immersed midship section of 302 square feet, and a displacement of 1062 tons. With 750 indicated horse power, she went 9 knots, giving a co-efficient, by the midship formula, of 293½, and by the displacement formula of 101. We are not about to deny that even worse performances by very small screw vessels have been recorded; but we may compare the results obtained from the *Water-witch* with the recorded performances of other vessels of nearly the same size. The general comparison is in this case against the *Water-witch*, although not in all cases so much against her as to warrant the conclusion that the jet system has proved a decided failure.

Name of vessel.	Length.	Beam.		Mean draft.		Midship section.	Displacement.	Indicated horse power.	Speed.
	ft.	ft.	ins.	ft.	ins.	sq. ft.	tons.		knots.
Water-witch ...	162	32	0	9	9	302	1062	750	9·
Royalist.	160	30	4½	14	0½	302	918	627	9·269
Rapid..............	160	30	4	13	10	293	894	505	8·888
Harrier.	160	31	10	14	4	350	1047	360	8·32
Fawn..............	160	31	10	13	11½	230	1004	374	8·578
Cruiser............	160	31	10	13	6½	332	1007	132	6·608
Columbine	160	30	4	13	10½	295	889	598	9 504
Alert	160	31	11	14	0½	333	1013	383	8·786
Shearwater......	160	30	4	13	9	291	885	532	8·957
Fox.................	159⅓	40	4	16	3½	449	1340	741	9·325
Rinaldo.	185	33	2	14	7½	367	1286	752	10·588
Serpent.	185	28	4	11	4	254	840	692	9·724
Rattler..	185	33	2	14	5½	360	1262	784	10·256
Chanticleer......	185	33	2	13	10½	343	1185	701	10·01

We might extend this list to other vessels and to other trials of the same vessels, but we have chosen those in which the midship section was nearest to that of the *Water-witch.* Considering that the speeds are, roughly, about as the cube root only of the power, we think there can be no doubt, apart from the theoretical examination we have made, that the *Water-witch*, although it may have done better than was expected, has nevertheless given but a very poor result. Mr. Phipps, who has arrived at the same conclusion, by a different mode of reasoning, has written us a letter, which is worthy the attention of our readers.

H. M. S. Water-witch.

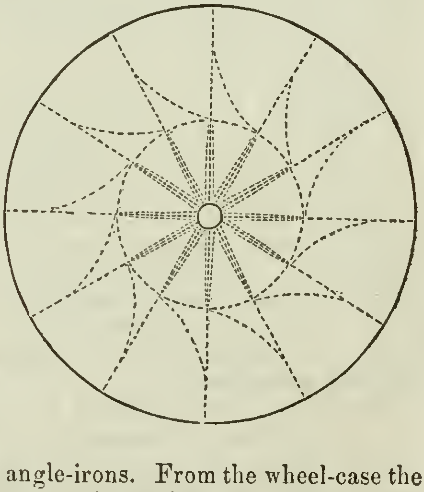
From the London Engineering, No. 43.

In the preceding columns we give an analysis of the result obtained, during her trial on Friday last, by H. M. S. *Water-witch*, a steam sloop fitted with Ruthven's hydraulic propeller, and we propose now to describe the machinery with which the vessel is fitted. A general account of the *Water-witch* and her propelling machinery appeared in this journal some months ago, (*vide Engineering*, vol. i., page 407.) The *Water-witch* was designed by Mr. E. J. Reed, and, as we stated in our former notice, she has been built by the Thames Iron Works and Shipbuilding Company. Her tonnage is 778 tons measurement, her length being 162 feet, her breadth 32 feet, and her depth 13 feet 9 inches. She has a flat bottom and is double-ended, each end being fitted with a rudder. She is armor-plated, for a length of about 60 feet amid-ships, with $4\frac{1}{2}$-inch plates, placed upon 10-inch teak packing, this armor-plating extending from about 3 feet below to 4 feet above the water-line, and at the forward and aft end of this central armor-plated portion, armor-plated bulkheads are carried across the vessel, that at the after end reaching only as far as the upper deck, whilst that at the forward end extends 5 feet 6 inches above it. This forward bulkhead is furnished with ports, so that guns may be pointed through it in a line with the keel and fired over the upper deck, the vessel being capable of being fought end on.

The propelling machinery was constructed by Messrs. J. and W. Dudgeon, according to the plans of Mr. Ruthven, and its arrangement consists of a set of three-cylinder condensing engines driving a centrifugal pump, by which the water is supplied to the jets which form the propelling power. Four parallel passages, made of boiler-plates and angle-irons, conduct the water to the centrifugal pump, the water being admitted into these passages through a number of gill-like openings formed in the forepart of the bottom of the vessel. These openings, which are very close together, were formed by cutting a number of transverse slits in the bottom plates, and then "dishing" up the metal between them, the amount that the plates are dished or bulged upwards increasing from the after-side of each slit to the foreside of the

one abaft of it. In this manner there are formed a number of openings of a segmental shape, the arched top of each being formed by the dished plate and the lower or straight edge by the unbent portion of that part of the plate which is dished to form the next opening. The plates in which the openings are formed are of Lowmoor iron. The parallel passages leading from the openings to the pump are each 3 feet $1\frac{3}{8}$ inches wide by 1 foot $11\frac{1}{2}$ inches deep in the clear, and they are each fitted with a sluice-valve by which the amount of water admitted can be regulated. The two outside passages are also fitted with sluice-valves, by means of which they can be placed in communication with the bilge, so as to draw their supply of water from it if necessary. Under the centrifugal pump the waterways are curved round in a spiral form, and their ends are furnished with inclines which assist in conducting the water smoothly up to the wheel of the centrifugal pump.

The revolving wheel of the centrifugal pump is 14 feet in diameter at the top, and 14 feet 3 inches in diameter at the largest part, and it has twelve arms, these arms, which curve both upwards and outwards, being secured by their edges to conical disks which form the upper and lower faces of the wheel. The water is guided by the waterways to a central opening at the underside of the wheel, and, being raised by the action of the latter, is delivered into a cast iron casing within which the wheel revolves. The lower central opening of the wheel is 6 feet in diameter, and the annular opening through which the water is discharged is 1 foot $10\frac{1}{2}$ inches deep, whilst the total depth of the wheel is 4 feet $8\frac{1}{2}$ inches. The wheel is made of wrought iron plates and angle-irons. From the wheel-case the water is conducted through two copper pipes, which leave the case tangentially, and are led with a spiral curve to the jets at the side of the vessel. The arrangement employed for directing the jets, either backward or forward, consists of a large two-way cock placed at each side of the vessel just within the delivering nozzles, and by turning these cocks the water can be delivered through either the forward or aft nozzles, or through one forward and one aft nozzle at pleasure. The cocks can be worked from the deck-level by means of suitable gearing. The delivering nozzles, which are situated close to the water-line, are of brass, and are protected by armor-plating. Their size is 2 feet 1 inch by 1 foot 7 inches, and their corners being rounded, their area is equal to that of a circle 2 feet in diameter, or about 452 square inches.



The engines first designed for driving the pump had two cylinders, each 44 inches in diameter with 4 feet stroke; but this design was departed from, and the three-cylinder arrangement adopted. The three cylinders, which are each $38\frac{1}{2}$ inches in diameter, with a stroke of 3 feet 6 inches, are placed horizontally, and are arranged so that their centre lines form angles of 120° with each other. Each cross-head works on a single slide placed on one side of it, and the three connecting-rods are all coupled to a single crank formed on the vertical shaft of the revolving wheel. Each of the journals of the shaft is furnished with a series of collars like the thrust bearing of a screw-shaft, these collars supporting the weight of the wheel, and resisting the downward pull caused by the action of the wheel upon the water.

The slide-valves are of the ordinary double-ported kind, and are contained in valve-chests placed above the cylinders. They have 1 inch lap and $\frac{1}{8}$ inch lead, and are all driven by a single eccentric of 3 inches throw, placed on the vertical shaft above the crank. The eccentric rods are coupled direct to the valve-spindles, there being no expansion gear, and reversing gear not being required, as the engines are always run in one direction. The cylinder steam-ports are 27 inches by $1\frac{1}{16}$ inch, and the exhaust-ports 27 inches by $4\frac{1}{2}$ inches. The engines have ordinary injection condensers, these being placed by the side of the cylinders. The air-pumps, which are 18 inches in diameter with a stroke of 1 foot 9 inches, are double-acting, and are also placed by the side of the cylinders, each air-pump being driven by means of a lever, the longer arm of which is connected by links to the cross-head of the corresponding cylinder. The air-pump valves are of india rubber. The feed-pumps are conveniently arranged in front of the air-pumps, the plunger of each feed-pump being reduced in diameter, and led through a stuffing-box at the end of the pump-barrel, so as to form the air-pump rod. As we have already stated, the side waterways leading to the main pump are furnished with sluices, so that they can be made to take their supply from the bilge, and this being the case, other bilge-pumps are rendered unnecessary.

The boilers, which are two in number, are placed abaft the engines, the tubes and furnaces running fore and aft, and the stoke-hole being abaft the boiler. Each boiler is 11 feet wide, transversely, by 10 feet 6 inches high, and the length of each is 9 feet at the bottom and 9 feet 8 inches at the top, whilst a space 3 feet wide is left between the pair. There are three furnaces in each boiler, each furnace being 3 feet wide by 3 feet high, and the grate bars being 6 feet 6 inches long. The back uptake is 1 foot 6 inches wide, and from it the tubes return over the furnaces in the usual manner, each boiler containing 358 tubes, 5 feet 10 inches long and $2\frac{1}{8}$ inches in diameter. The coal is carried in bunkers extending across the vessel ahead and abaft the engine room.

The Breaking of Railway Axles. By Henry Simon.

From the London Engineering, No. 43.

The following extract from an official paper issued by the Association of German Railways, on broken axles, in 1865, may be interesting:

The returns are from twenty-three railway companies, and give a total number of one hundred and fifty-three breakages, besides forty cases discovered before complete breakage occurred.

Of these one hundred and fifty-three cases, thirty-four happened in September, October, November; forty-five in December, January, February; thirty-six in March, April, May; thirty-eight in June, July, August.

The average time of use before breakage was nine years and eleven months.

The longest time was twenty-one years four months.

The shortest only five months.

The average mileage was 104,780 English miles.

The greatest mileage was 332,580 English miles.

The axles were:

	English miles.
In 17 cases of cast steel, and ran an average of	85,171
1 case of cast steel (hardened)	93,339
46 cases of wrought iron (hammered)	114,575
38 " wrought iron (rolled)	103,311
48 " wrought iron (not stated whether rolled or hammered)	131,918
3 " hollow axles	90,252

The consequences of the breakages were:

In 5 cases the carriage or wagon got off the line, without any damage.

In 37 cases the carriage was more or less damaged.

In 9 cases several carriages were damaged, including one case where 19 carriages were injured.

No lives were lost.

98 cases happened with trains at full speed.

16 cases near stations, *i.e.*, at low speed.

24 cases were found out during the stoppage of trains in stations.

15 cases occurred during shunting.

The probable cause of breakage was:

In 17 cases bad workmanship of axle.

In 32 cases bad material

In 21 cases bad design.

In 6 cases overloading.

In 10 cases want of grease or oil.

In 46 cases too long use.

In 3 cases breakage of another axle.

MECHANICS, PHYSICS, AND CHEMISTRY.

A New Era in Illumination.—Wilde's New Magneto-electric Machine. By WILLIAM CROOKES, F.R.S.

From the London Journal of Science, October, 1866.

In the first number of this *Journal*, an article "On Light-house Illumination by Magneto-electricity" was contributed by Dr. Gladstone. Nearly three years have elapsed since that time, and a very important result in this branch of science having recently been obtained, it seems a fitting opportunity again to draw attention to the subject as an introduction to our more immediate topic.

The experience of the last two or three years in the use of the electric spark in light-houses has brought prominently forward several disadvantages and objections under which it labors. The advantages are many and obvious, and were well summarized in Dr. Gladstone's article, and were amply sufficient to justify the English authorities in persevering attempts to introduce this light into practice. In 1855, while corresponding on this subject with the late hydrographer to the Admiralty, Admiral Washington, Mr. T. Stevenson stated: "What we want is powerful apparatus, not intricate distinctions. To be enabled to see a light in a thick night, though it be only half a mile further than at present, may be of incalculable moment. If, therefore, we can increase the power of our lights so as to make them pierce the gloom but that fraction of a mile further than they do at present, we are moving in the right direction. On that small amount of extra offing hundreds of lives may depend." It would appear as if the electric light was pre-eminently adapted to meet a case like this; but recently doubts have been thrown on its superiority over oil in penetrating fog. In 1865, Mr. Berthon, the Secretary to the Trinity House, said, that, for a limited range of from nine to ten miles, the electric is immensely superior to any other light, but beyond that distance it appears to lose in a great degree its power, until at eighteen or twenty miles it is not very different to any ordinary first-class light; and Mr. Stevenson likewise states, that at great distances the oil light maintains its power better than the electric. Such a phenomenon certainly seems to be very improbable, although it may be the case that the rays proceeding from the electric light suffer so much more from absorption, in passing through an obstructive medium, than those from a flame produced by the consumption of oil, as to leave the oil light the more powerful of the two at great distances. If this were really so, it would follow that the application of the electric spark to light-house illumination is based upon a fallacy. The mere glare or splendor of effect to a near observer, so far from being an advantage to the mariner, is a positive evil, because, by its lustre, it tends to destroy his powers of perception of objects in the water that are nearer his view, and which, therefore, from their proximity, threaten more immediate danger to the safety of his vessel. All the mariner requires is distinct visibility. The really useful

WILDE'S MAGNETO ELECTRIC MACHINE

Fig. 2

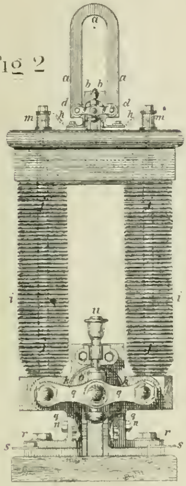


Fig. 3

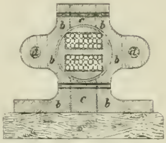


Fig. 4

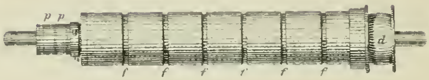
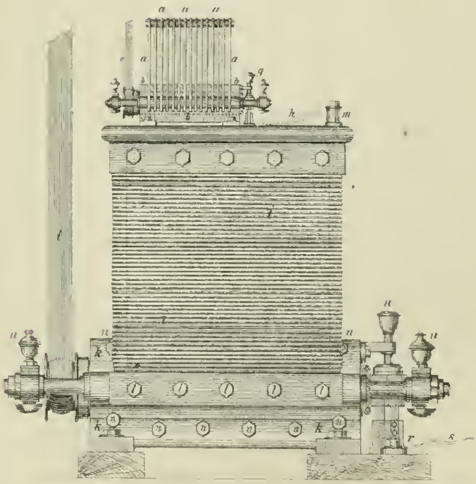


Fig. 1



power is that of penetration through an obstructing medium, and, therefore, the true measure of the usefulness of any light is the distance to which it remains distinctly visible, and at which it preserves its characteristic appearance. This objection to the electric light has only been made within the last year or so, and is apparently irreconcilable with the statements respecting its brilliant visibility at great distances, upon which so much stress was laid on its first introduction.

Other difficulties have also been met with. The kind of knowledge and attention required to render the magneto-electric light constant and sure is far above that necessary with the most elaborate oil lamp; and the uncertainty to which the use of machinery of any kind is inherently liable, independently of the necessity of maintaining a constant supply of water, and the great difficulty of repairing and renewing the steam engines and magneto-electric machines when required, all contrast most unfavorably with the certainty and simplicity attending the present oil lamp system. To this must be added the constant difficulty experienced in maintaining a class of persons for so responsible an office as that of engineer or attendant. A light-house, from its special nature, its great importance, its uninterrupted action, and its isolated position, is, in the language of Dr. Faraday, the last place to which processes comparatively new in their nature should be applied, if there be any other educational positions which can precede such application. Now, in spite of all the care which the importance of the subject has rendered necessary, the Dungeness electric light entirely failed or was inefficient for upwards of $119\frac{1}{2}$ hours, between August, 1863, and October, 1864; and, referring to this, the Elder Brethren of the Trinity House say that it appears to them to be impossible to obtain entire immunity from such accidents, so long as human nature is subject to infirmity. These fallings off and cessations have frequently rendered it necessary that the ordinary oil lamps should be lighted, and, notwithstanding the power of the magneto-electric light, instances have occurred of vessels being stranded near Dungeness. This liability to occasional failure is a matter for grave consideration in respect to the development of the magneto-electric light as an element of light-house illumination.

Under these circumstances the Elder Brethren stated, on January the 18th, 1865, in answer to an inquiry from the Marine Department of the Board of Trade, that they are induced "to adhere to the opinion expressed to their Lordships in their letter of the 8th of April, 1863, that they are not prepared to recommend the adoption of the magneto-electric principle for light-house illumination." This opinion was repeated on the 15th of March, 1865, when the Secretary of the Trinity House wrote as follows:

"There are numerous other causes of minor importance which have led the Elder Brethren to the decision expressed in my letter of the 18th of January, which can only be duly weighed and appreciated by those on whom the responsibility of working, and, above all, of maintaining the lights is placed, and, as already expressed in their letter of 8th

of April, 1863, the Elder Brethren feel that there are no advantages which can counterbalance the want of certainty in light-house illumination."

Meantime, a somewhat modified system of illuminating light-houses by electro-magnetic apparatus has been successfully exhibited at Havre, in France, and the Commissioners of Northern Light-houses suggested that their engineer should be sent over to report upon it. It appeared that the plan adopted was very similar to that of Mr. Holmes, and that M. Berlioz had only made a few improvements upon it. Mr. Holmes being of opinion that he could now supply a better machine than the one in use at Havre, it was considered that it would be a national discredit and an act of injustice to that gentleman, if, under these circumstances, the foreign system were adopted. It was therefore decided at the latter end of last year that an entirely new system of apparatus, including lamp, machines, and engine, should be procured from Mr. Holmes; that the eminent optical engineer, Mr. James Chance, should be asked to put into practice certain opinions which he has always held respecting the size of the lens required, and the arrangement of curvature, he undertaking to supply an instrument which should be entirely suitable, whilst the Elder Brethren proposed to combine with this new apparatus a thoroughly independent system of management, which they trust may result in the establishment of the magneto-electric light as a useful component of light-house illumination.

Early in the present year, rumors of Mr. Wilde's new electro-magnetic apparatus were first heard, and Mr. Thomas Stevenson was instructed to visit Manchester to report on the same. He was so very favorably impressed with the apparatus, that it was considered indispensable to a proper series of experiments that it should be tested along with Professor Holmes'. An estimate was accordingly obtained from Messrs. Wilde, and their offer was at once accepted.

The light from Messrs. Wilde's large machine, which Mr. Stevenson saw, is the most powerful artificial light which has ever been produced, giving about eight times the light of the magneto-electric machines now in operation, and it was therefore not considered desirable to suggest the use at present of that sized machine for light-house purposes. A machine about half the power of the large one was recommended, as by a simple arrangement the brilliancy of the light, and the power required to drive the machine, could be varied at pleasure, to suit the different conditions of the atmosphere, and with it requirements could be met which would be beyond the power of any other description of machine. The dimensions of such a machine would be—length 64 ins., width 20 ins., height 48 ins., and the cost £1,000. Ultimately a machine of half this power, to cost £500, was decided upon, and when the writer had the pleasure of visiting Messrs. Wilde's workshops, and the advantage of listening to the inventor's lucid description of his large machine, the one being made for the Commissioners of Northern Light-houses was far advanced towards completion.

Like most practical applications of science, the important results

which Mr. Wilde has obtained depend more upon an ingenious combination of several known facts, united with considerable engineering skill, than upon any really new and striking discovery in the science. The principle of the machine can be expressed in a few words. It consists in the application of the current from an electro-magnetic machine, armed with permanent magnets, for the purpose of exciting a powerful electro-magnet; this electro-magnet being now used as the basis of a still larger electro-magnetic machine, for the purpose of having induction currents generated by its agency. In other words, by well-known means, an electric current can be obtained by the rotation of an armature close to the poles of a magnet. If this electric current be passed round an electro-magnet, it may be made to produce a far greater amount of magnetism than was possessed by the first magnet. There is no difficulty, therefore, in comprehending how, by the mere interposition of a rotating armature, and the expenditure of force, a small and weak magnet may be made to actuate a very powerful magnet. But as the power of the magnet increases, so does the power increase of the electric current which may be generated by induction in an armature rotating between its poles. We have, therefore, only to pass this No. 2 induced current from No. 2 magnet round a still larger magnet No. 3, and by rotating an armature between its poles we can get a still more energetic induced current No. 3. Theoretically there is no limit to this plan. It is a species of involution; and when it is considered that each conversion from magnet No. 1 to magnet No. 2, &c., or from induced current No. 1 to induced current No. 2, &c., multiplies the power very many times,* it will not be considered surprising that after three involutions the induced current possesses such magnificent powers.

Some erroneous opinions are pretty generally entertained as to the actual discovery claimed by Mr. Wilde, and the splendor of the result, for achieving which he deserves the very highest credit, is liable to cause early investigators in the field to be overlooked. This would be most unfair; for it is through their instrumentality that the way has been paved for the success now achieved. In 1838 the Abbés Moigno and Raillard† proved that, by taking an electro-magnetic machine, the original magnet of which would only support a few grammes, and passing the electric current generated by it round a large electro-magnet, the latter could be made to support a weight of 600 kilogrammes. The Abbés carried the multiplication of power only so far as to obtain the more powerful magnet No. 2 from the weak magnet No. 1.

Electro-magnets of extraordinary power, with coils arranged longitudinally, instead of transversely, on their armatures, had been made by Mr. Joule. Magneto-electric machines, with revolving armatures, in which electro-magnets had been substituted for permanent magnets, had been constructed by Dr. Page and Prof. Wheatstone. Magneto-

* We say very many, but we have absolutely no data to guide us to a near approximation.

† Moigno's "Télégraphie Electrique," page 15. Paris: 1849.

electric machines had been made to act on electro-magnets in various telegraphic instruments by Wheatstone, and subsequently by others; and Dr. Page, as well as the experimentalists above mentioned, had observed the important fact that an electro-magnet excited by a magneto-electric machine became capable of effects greatly exceeding those of the original magnet. The peculiarly constructed armature employed by Mr. Wilde is likewise essentially identical with Siemens' helix, a full description of which may be seen in Siemens' patent, and also in the fifth volume of Du Moncel's "Applications de l'Electricité," page 249, published in 1862. It is, however, right to say, that Mr. Wilde, in his patent of February 25, 1863, expressly states that he makes no claim to the peculiar construction of the armature.

By the kindness of Mr. Wilde, we are enabled to give our readers a full description, with drawings, of the machine now in process of manufacture for the Northern Light-house. Plate V., Fig. 1 represents a side view, and Fig. 2 an end view of the machine, the letters referring to the same parts in each, *a a a a* are 16 permanent magnets, bolted on to the magnet cylinder *b*, shown in magnified section at Fig. 3. The magnets weigh about 3 lbs. each, and will support a weight of about 20 lbs. In the magnet cylinder the part *b b* is iron and *c c* brass, and it is so arranged that *b b*, being screwed on to the respective poles of the magnets at *d*, form one entire north pole and one entire south pole to the 16 magnets, separated from each other by the brass pieces *c*. A circular hole, $2\frac{1}{2}$ inches in diameter, is bored lengthways through the metals, so as to form them into a hollow cylinder of brass and iron. Fig. 4 represents the armature, a transverse section of which is also shown in its place inside the hollow cylinder, Fig. 3. It consists of a cylinder of cast iron, about one-twentieth of an inch less in diameter than the hole in the cylinder *b c b c*, so that it may revolve in very close proximity to the interior of the hollow cylinder without touching it, being held at each end by appropriate brass supports, in which the axis of the cylinder works. At one end of the armature is a cylindrical prolongation *d*, on which a pulley *e* works, and at the other end is fixed a commutator. About fifty feet of insulated copper wire, one-eighth of an inch in diameter, are wound upon the armature in the direction of its length, as shown in Fig. 4, and in section in Fig. 3. The inner extremity of the wire is fixed in good metallic contact with the armature, the other end being connected with the insulated half of the commutator. Bands of sheet brass, *f f*, are bound at intervals round the armature, in grooves sunk in it for that purpose, their object being to prevent the convolutions of insulated wire from flying out of position by centrifugal force when in rapid rotation.

By means of the small strap *e* the armature is made to revolve in the interior of the magnet-cylinder at about 2500 revolutions per minute. During each revolution, two waves of electricity, moving in opposite directions, are induced in the insulated copper wire surrounding the armature. The rapid succession of alternating waves thus generated at the rate of 5000 per minute are, by means of the commutator

at g, converted into an intermittent current moving in one direction only, which is conducted along the wires h.

The electro-magnetic machine by which the light is produced is of precisely the same construction as the magneto-electric machine just described, except that an electro-magnet i is substituted for the permanent magnets $a\ a$. The electro-magnet i, Figs. 1 and 2, is formed of two rectangular plates j of rolled iron, 36 ins. in length, 26 ins. in width, and 1 in. in thickness, as shown by the dotted lines. They are bolted, parallel with each other, to the sides of the magnet cylinder k by means of the bolts l, and the plates are connected together at their upper extremities by being bolted to a bridge formed of two thicknesses of the same iron as that of which the sides are made. All the component parts of the electro-magnet, requiring to be fitted together and to the magnet cylinder, are planed to a true surface, for the purpose of ensuring intimate metallic contact throughout the entire mass.

Each of the sides of the electro-magnet is coiled with an insulated conductor, consisting of a bundle of seven No. 10 copper wires, laid parallel to each other, and bound together with a double covering of linen tape. The length of conductor coiled round each side of the electro-magnet is 1650 feet. Two of the extremities of the coils are connected together so as to form a continuous circuit 3300 feet in length. The other extremities of the coils terminate in the two insulated metal studs $m\ m$, fixed upon the wooden top of the machine, and connected thereby with the wires $h\ h$. The total weight of the two coils of insulated copper wire, without the iron, is half a ton. The diameter of the hole in the magnet cylinder is 7 ins., and its length 35 ins. The separate parts of the cylinder are bolted together at the top and bottom by means of 12 copper bolts n, three-quarters of an inch in diameter. The armature o, which is an exact fac-simile, except as regards size, of the one already described, is about one-eighth of an inch less in diameter than the bore of the magnet cylinder. It is wound with an insulated strand of copper wire, 350 feet in length and a quarter of an inch in diameter, as shown in section in Fig. 3. A pulley d, 7 inches in diameter, is keyed upon one end of the armature, and upon the other end are fixed two hardened steel collars $p\ p^1$, one of which is insulated from the armature axis. These form part of the commutator, by means of which the rapidly alternating currents are converted into an intermittent current moving in one direction only. These currents of electricity, which produce the light, are taken from the steel collars by means of the springs $q\ q$, and thence to the screw nuts at r, from which they can be conveyed to any place required by the conductors $s\ s$.

The armature of the 7-inch machine is driven at 1800 revolutions per minute by means of the strap t, from the same shaft as the magneto-electric machine. Reservoirs for oil are shown at u. The total weight of the machine complete is a little more than 1 ton.

The action of the machine will be readily comprehended from the explanation previously given. The electricity induced from the permanent magnets $a\ a\ a$, in the rotating armature of the small machine,

is transmitted, by means of the wires *h h*, through the coils of the large electro-magnet of the 7-inch machine, the iron plates and magnet cylinder of which acquire an enormous amount of magnetism. Simultaneously a porportionately larger amount of electricity is induced in the wires of the larger armature, and this current of electricity is used for producing the light. When the machine is in full action, an engine of about three horse power will be required to drive it, and the lamp will consume sticks of carbon at least $\frac{3}{8}$ inch square. The power of the machine may be regulated according to the quantity of light required to suit the different conditions of the atmosphere, by placing small blocks of iron on the top of the small magnet cylinder *b b*, so as to connect the opposite poles, and proportionately diminish the power of the induced current in the armature.

This machine is, as already mentioned, considerably smaller than the one now in existence. In the former there are only two conversions; that is to say, a permanent magnet—an induced current of electricity—an electro-magnet—a more powerful induced current. In the large machine there is a still further multiplication of force. Its small magneto-electric machine has an armature of $1\frac{5}{8}$ inch diameter, armed with six small permanent magnets, weighing 1 lb. each. The induced current from this is transmitted through the coils of the electro-magnet of a 5-inch* electro-magnetic machine, and the direct current from the latter is simultaneously, and in like manner, transmitted through the coils of the electro-magnet of a 10-inch machine. The weight of the electro-magnet of the 10-inch machine is nearly three tons, and the total weight of the instrument is about $4\frac{1}{2}$ tons. The machine is furnished with two armatures—one for the production of "intensity" and the other for the production of "quantity" effects. The intensity armature is coiled with an insulated conductor, consisting of a bundle of thirteen No. 11 copper wires, each 0·125 of an inch in diameter. The coil is 376 feet in length, and weighs 232 lbs. The quantity armature is enveloped with the folds of an insulated copper plate conductor 67 feet in length, the weight of which is 344 lbs.

With the three armatures driven at a uniform velocity of 1500 revolutions per minute, an amount of magnetic force is developed in the large electro-magnet far exceeding anything which has hitherto been produced, accompanied by the evolution of an amount of dynamic electricity from the quantity armature, so enormous as to melt pieces of cylindrical iron rod fifteen inches in length and fully one-quarter of an inch in diameter, and pieces of copper wire of the same length and one-eighth of an inch in diameter. With this armature in, the physiological effects of the current can be borne without inconvenience; immediately after 15 ins. of iron bar had been melted, the writer grasped the terminals, one in each hand, and sustained the full force of the current. The shocks were certainly severe, but not inconveniently so.

When the intensity armature was placed in the 7-inch magnet cylin-

* For the sake of convenience, the different sized machines are distinguished by the calibre or bore of the magnet cylinders.

der, the electricity melted 7 feet of No. 16 iron wire, and made a length of 21 feet of the same wire red-hot. The illuminating power of the current from this armature was of the most splendid description. When an electric lamp, furnished with rods of gas-carbon half an inch square, was placed at the top of a lofty building, the light evolved from it was sufficient to cast the shadows of the flames of the street-lamps, a quarter of a mile distant, upon the neighboring walls. When viewed from that distance, the rays proceeding from the reflector have all the rich effulgence of sunshine. With the reflector removed from the lamp, the bare light is estimated to have an intensity equal to 4000 wax candles. A piece of ordinary sensitized paper, such as is used for photographic printing, when exposed to the action of the light for 20 seconds, at a distance of 2 feet from the reflector, was darkened to the same degree as a piece of the same sheet of paper was when exposed for a period of one minute to the direct rays of the sun at noon on a very clear day in the month of March. The day on which the writer saw the machine at work, (towards the end of June,) the mid-day sun was shining brightly in at the window. He took the opportunity of roughly comparing the intensity of the sun with that of the electric light armed with the reflector. From a comparison of the shadows thrown by the same object, it appeared to him that the electric light had between three and four times the power of the sunlight. That the relative intensities were somewhat in this ratio, was evident from the powerful scorching action the electric light had on the face, and the ease with which paper could be set on fire with a burning-glass introduced in the path of its rays.

The extraordinary calorific and illuminating powers of the 10-inch machine are all the more remarkable from the fact that they have their origin in six small permanent magnets, weighing only 1 lb. each, and only capable at most of sustaining collectively a weight of 60 lbs. When working up to its full intensity, it requires an engine of about 7 horse power to drive it.

The physicist will, at first sight, consider that the intimate connexion between the consumption of so large an amount of mechanical power, and the evolution of so enormous an electrical force, is a necessary consequence of the modern doctrine of the conservation of force. But, without for a moment denying the truth of this doctrine, it must be admitted that there are certain phenomena connected with this machine which are in apparent contradiction to the law of conservation.

A phenomenon already obtained on a small scale by Jacobi, Lenz, and Miers, is rendered visible in the most striking manner by means of this machine. When the wires, forming the polar terminals of the small exciting magneto-electric machine, were connected for a short time with those of the large electro-magnet, and then disconnected, a bright spark could be obtained, from the wires of the electro-magnet, 25 seconds after all connexion with the magneto-electric machine had been broken.

It will be of interest, apart from all questions as to economical production, to ascertain what is the theoretical quantity of coal required

to be consumed in the production of this amount of electric force. Mr. Wilde says that a 7 horse power engine is required to drive the machine. One horse power is equal to 1.980,000 foot-pounds per hour; that multiplied by seven is 13,860,000 foot-pounds per hour, which therefore represents the actual power required to drive the machine. Now, by multiplying the British Fahrenheit units of heat produced by the combustion of one pound of coal, by Joule's equivalent, or 772 foot-pounds, the result will be the total heat of combustion expressed in foot-pounds. In the best coal this is as high as 12,000,000 foot-pounds. We arrive, therefore, at the startling conclusion, that, to overcome the friction of the different parts of the machine; to whirl a mass of metal, weighing several hundred weights, round with a velocity of 1500 revolutions per minute; to generate a current of electric force far surpassing anything ever before produced; and, after allowing for the waste inherent in its passage through the conducting wires and electric lamp, to cause it to blaze forth with an intensity of light, before which the rays of the sun himself appear pale and feeble; to keep up this intense development of energy for one hour, requires an expenditure of force represented by the combustion of less than 18½ ounces of coal!

This is the theoretical calculation; but if reduced to actual practice, the results are scarcely less astonishing. The economy of the power actually employed by Mr. Wilde cannot be calculated, as the engine is a 60 horse one, and is used for driving the very heavy machinery of a wire mill, as well as performing the various operations required in an engineer's workshop; but the *efficiency* of an engine, *i.e.*, the ratio of the work actually performed to the mechanical equivalent of the heat expended, is well known, and varies in extreme cases between the limits 0·02 and 0·2. Taking an average efficiency as 0·1, or one-tenth, we find that the ordinary consumption of coal required to work a 7 horse power engine, midway between excessive wastefulness on the one hand, and rigid economy on the other, is $10 \times 18\frac{1}{2}$ ounces, or 11½ lbs. of coal per hour, worth about one halfpenny.

The above expense of one halfpenny per hour for coal is, of course, only one item in the cost. To it must be added the expense of carbon rods for the lamp, which will be about 10 ins. per hour, worth perhaps a penny. There must also be added interest of the cost of purchase of machines, expense of maintenance and repairs, which will perhaps bring up the total expense per hour to sixpence or eightpence. Comparing this with the hourly expense of the electric lights already in existence, we find, according to the Abbé Moigno, that the French machine costs altogether sixpence per hour for a light equal to 900 wax candles, whilst the actual working expenses of maintaining the electric light at Cape La Hève, during a period of 27 months, have been, exclusive of salaries, about one shilling per hour, or, inclusive of salaries, two shillings.*

According to a calculation made by the Abbé Moigno, respecting

* "Mémoir sur l'Eclairage et la Balisage des Côtes de France," par M. L. Reynaud, p. 149. Paris: 1865.

the economy of the light evolved by the French machines, and altering the figures to suit the present case, it appears that to maintain a light equal to 4000 wax candles for one hour, would cost, with gas, £1 2*s*. 6*d*.; with Colza oil, £1 7*s*.; and with the electrity produced by a Bunsen's pile, £1 15*s*. 6*d*.

The annual expenditure at a first-class light-house, on the old system, is, on an average, £400 per annum, and, on the assumption that the light burns for 4000 hours per annum, that would come to two shillings per hour. The expenses of the old and the electric system are, therefore, not very dissimilar, and the problem of the adoption of electricity to supersede oil must be decided on grounds of convenience and efficiency alone.

The great advantage of Mr. Wilde's over the old system of magneto-electric machine, appears to be that it is capable of amplification to any required power, by a mere enlargement of the size of the different parts. His largest machine weighs about 3 tons. If, instead of using the electric current generated by it to produce dynamic effects, we pass it round a still larger electro-magnet, we should at once produce a vastly greater development of force. The only limit which we see to this multiplication of power, is the excessive heat which would be developed in the rotating armatures. It would be an interesting problem to calculate what would be the result of driving the 32-inch armature, required for a 100-ton magnet, with (say) a 1000 horse power steam engine. If the power generated by this machine did not at once burn up the working parts, dissipate the electric lamp and conducting wires with a mighty explosion into space, and strike dead all the attendants with one lightning flash; if it were at all manageable, and were put on a high tower, it would probably give light enough to make London by night considerably brighter than London by day.

Space will not admit of the enumeration of all the uses to which so convenient and economical a light may be applied. Moreover, this is a subject which has been so frequently discussed that any enumeration here would become a mere repetition. One practical application has, however, been made, which possesses great interest. Photographers are finding that it is more convenient than the sun. According to the *Photographic News*, we learn that an establishment has been organized at Manchester, in which is fitted up the first of Mr. Wilde's machines for supplying the electric light. By the aid of this, more than two hundred negatives can be exposed in a day, to secure gelatine reliefs. This is the first practical application of the electric light to the commercial working of photography, its constancy rendering it here more valuable than an uncertain sunlight.

The purely scientific interest of this discovery has been scarcely touched upon. Of this more will be said hereafter. To physicists and experimentalists in magnetism the gigantic magnetic force developed in the 3-ton magnet will afford an opportunity, which will doubtless at once be seized, of repeating and extending the classical researches of Dr. Faraday in Diamagnetism and the Magnetic Condition of all Matter.

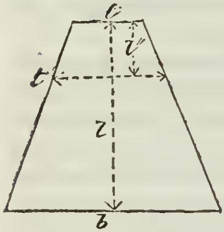
For the Journal of the Franklin Institute.

Problems in Mensuration.

To divide the surface of a trapezoid into any number of equal parts, by lines parallel to the top and bottom.

Call l'' the length of first part from top; then, if it is divided into two parts, we have—

$l''=\left(\sqrt{\frac{b^2+t^2}{2}}-t\right)\frac{l}{b-t}$, and for five parts $l''=\sqrt{\frac{b^2+4t^2}{5}}-t\Big)\frac{l}{b-t}$,



$$l'''=\sqrt{\frac{2\,b^2+3\,t^2}{5}}-t\Big)\frac{l}{b-t},$$

$$l^{\text{iv}}=\sqrt{\frac{3\,b^2+2\,t^2}{5}}-t\Big)\frac{l}{b-t},$$

$$l^{\text{v}}=\sqrt{\frac{4\,b^2+t^2}{5}}-t\Big)\frac{l}{b-}t,$$

And the value of t'', t''', &c., is always the corresponding quantity under the radical.

When the figure is an isosceles triangle, the value of $t=0$, and the formulas reduce to simpler forms.

To divide the frustrum of a cone or pyramid into equal parts, by planes parallel to top and bottom.

Into two parts, $l''=\left(\sqrt[3]{\frac{b^3+t^3}{2}}-t\right)\frac{l}{b-t}$.

Into five parts, $l''=\left(\sqrt[3]{\frac{b^3+4\,t^3}{5}}-t\right)\frac{l}{b-t}$,

$$l'''=\left(\sqrt[3]{\frac{2\,b^3+3t^3}{5}}-t\right)\frac{l}{b-t},$$

$$l^{\text{iv}}=\left(\sqrt[3]{\frac{3\,b^3+2t^3}{5}}-t\right)\frac{l}{b-t},$$

$$l^{\text{v}}=\left(\sqrt[3]{\frac{4\,b^3+t^3}{5}}-t\right)\frac{l}{b-t}.$$

And the value of t'', t''', &c., is always the corresponding quantity under the radical.

In case of a cone or pyramid the value of $t=0$, and the formulas reduce.

To increase the solidity of a frustrum of a cone or pyramid any number of times by addition to the large end.

To double it, $l'=(\sqrt[3]{2\,b^3-t^3}-t)\frac{l}{b-t}$.

To quintuple it, $l'=(\sqrt[3]{5\,b^3-4\,t^3}-t)\frac{l}{b-t}$.

To double the area of the figure by prolonging the sides with a new base, parallel to the top and bottom.

$$l'' = (\sqrt{2\,b^2 - t^2} - t)\,\frac{l}{b - t}.$$

To quintuple, $l^v = (\sqrt{5\,b^2 - 4\,t^2} - t)\frac{l}{b - t}.$

And the *quantity under the radical* is the length of the new base.

G. D.

Waste of Platinum in Sulphuric Acid Manufactories.

From the London Mechanics' Magazine, April, 1866.

Some few years ago M. Scheurer-Kestner, of Thann, made some careful researches as to the *amount* of the waste of platinum in sulphuric acid manufactories in which platinum alembics were used, and he found that, in an apparatus which, when regularly worked, yielded 4000 kilogrammes of concentrated acid per day, each 1000 kilogrammes of acid dissolved and carried away about two grammes of platinum, when the acid was tolerably free from nitrous vapors, and as much as four or five grammes of platinum when the acid was no freer from nitrous vapors than it is usually. He accordingly recommended that sulphate of ammonium should always be added to the sulphuric acid in the alembic, that salt being decomposed by the nitrous vapors, and its base combining with them and thereby rendering them inert. He found that the waste of platinum was very greatly diminished when this expedient was adopted. He found, too, that *new* alembics undergo less rapid waste than those which have been in use for some time, freshly-hammered platinum being more compact, and so less easily attacked by solvents, than platinum which has been long in use. Another most interesting fact which he established is, that platinum containing iridium is much more durable than platinum alone. He put into a still kept constantly at work, and so kept immersed in boiling sulphuric acid for two months, two capsules, one of pure platinum, and the other of platinum alloyed with iridium. At the end of the two months the capsule of pure platinum was found to be greatly deformed and its surface considerably corroded, and to have lost 19·66 per cent. of its weight, while the capsule of iridio-platinum retained its original form and brilliancy of surface quite unimpaired, and had lost only 8·88 per cent. of its weight. Since then, nearly all the platinum worked into alembics on the continent has been alloyed with a small portion of iridium.

Egyptian Bricks. By Professor UNGER.

From the Civil Engineer and Architect's Journal, September, 1866.

Prof. Unger, in a paper recently communicated to the Imperial Academy of Sciences, at Vienna, shows that Egyptian bricks possess a special interest, for they contain a variety of evidence preserved, as it seems, in an imperishable form. In his latest researches he has examined a brick from the pyramid of Dashour, which dates from between 3,400 and 3,300 B.C., and found imbedded among the Nile mud or slime,

chopped straw, and sand of which it is composed, remains of vegetable and animal forms, and of the manufacturing arts, entirely unchanged. So perfectly, indeed, have they been preserved in the compact substance of the brick, that he experienced but little or no difficulty in identifying them. By this discovery Prof. Unger makes us acquainted with wild and cultivated plants which were growing in the pyramid-building days; with fresh water shells, fishes, remains of insects, and so forth, and a swarm of organic bodies, which, for the most part, are represented without alteration in Egypt at the present time. Besides two sorts of grain—wheat and barley—he found the teff, the field pea, the common flax, the latter having, in all probability, been cultivated as an article of food, as well as for spinning. The weeds are of the familiar kinds: wild radish, corn chrysanthemum, wart-wort, nettle-leaved goosefoot, bearded hare's ear, and the common vetch. The relics of manufacturing art consist of fragments of burnt tiles, of pottery, and a small piece of twine spun of flax, and sheep's wool, significant of the advance which civilization had made more than five thousand years ago. The presence of the chopped straw confirms the account of brick-making as given in Exodus and by Herodotus; and the whole subject is so interesting that it is pleasing to know that Prof. Unger intends to follow it up. He is of opinion that, by careful examination of a large number of bricks, some light may be thrown on the origin of Egyptian civilization.

MISCELLANIES.

Protection of Wood against Insects.—The *Cosmos* mentions the report of a committee appointed to examine into the means of protecting carved wood against the ravages of insects, and of remedying the injury already done to ancient carvings. The committee report:

"1. That the worm may be destroyed by vapors, and especially by the vapor of benzine.

"2. The wood may be restored by saturating it with a strong solution of corrosive sublimate. To restore the color, which is injured by the mercury, ammonia is used, and then a light dose of hydrochloric acid. The wood is then to be injected with gum and gelatine to fill up the holes and strengthen the texture of the wood, and then varnished.

"But gilded work is very difficult to restore."

Would it not be well to prepare all carved wood beforehand by injecting, by Breant's process, a metallic solution, the nature of which might be altered according to the color desired? This process can be applied without injury to the most delicate carving, and would serve as an effectual preservative.

New Stuffing Box.—A correspondent of the *Cosmos* speaks in very glowing terms of the success of a new stuffing box, which appears to be coming into use on the French locomotives. He describes it as follows: The box is bored out in a conical form, and the cavity, in place

of hemp, is filled by a "cylindro-conic apparatus," through which the piston-rod passes. This piece is of anti-friction metal, and is cut in bevel in the direction of its length so as to form the parts which, when united, press outwards upon the conical surface of the box. The steam presses them forcibly against this, and at the same time forces the two parts into close contact by sliding over each other, so as to embrace the rod tightly. A spiral spring holds the plug in place when no steam pressure is on. It is said that these boxes have been in use for eighteen months without being unscrewed, and without allowing any escape of steam, and that the piston-rods are not in the least scratched or worn by it.

Spectrum of Steam.—Professor Janssen reports to the Academy of Sciences, of Paris, an interesting experiment made to determine whether the dark rays of the solar spectrum, which have been shown to be due to the earth's atmosphere, and are, therefore, called the atmospheric or *telluric* bands, are due to the watery vapor. For this purpose an iron tube of 37 metres ($39\frac{1}{2}$ yards) long, packed in a box of sawdust to prevent radiation of heat, and closed at the ends by glass plates, was filled with steam of seven atmospheres pressure, and the light of sixteen gas-burners passed through it and formed a spectrum. By comparison with the solar spectrum it seemed that Fraunhofer's group A, the greater part at least of B, the group C, and the groups between C and D are due to the watery vapor. It was also seen, that while the transmitted light was dull in the most refrangible part of the spectrum it was bright in the red and orange; so that, although the steam absorbs energetically certain red and yellow rays, it is, on the whole, very transparent for the greater part of these rays, while it acts in a general way upon the most refrangible rays; consequently, the color of steam seen by transmitted light would be orange-red, and the redder the longer the column.

Crystallization of Red Phosphorus.—M. Blondlot has succeeded in crystallizing red phosphorus which has hitherto been considered amorphous by sublimation in an atmosphere of nitrogen. He introduces about 2 grammes into a small mattrass, and then closes the neck hermetically by fusion, which can be done without igniting the phosphorus, provided the mattrass be held vertically. Allowing the apparatus to stand, it fills with white vapors, luminous in the dark, which are due to the oxidation of the phosphorus, and in twenty-four hours all the oxygen of the air is absorbed. The phosphorus may then be melted in a water-bath, while the upper part of the mattrass is protected from the heat. The phosphorus is deposited in transparent crystals of a cubical form, which, in a few days, form magnificent arborescences, and shine with the lustre and color of the diamond. This state may be preserved by avoiding the light, but by the sun-light, or even by diffused light, they pass to a brilliant garnet-red color and resemble rubies. A crop of colorless crystals may be got upon the surface of these.

Means of Reducing the Heat and Light of the Sun's Rays.—M. Foucault had made a great improvement in reflecting telescopes, by making the reflecting surface by depositing a thin coating of silver upon glass. This coating is so thin as to be transparent to a certain extent, with a beautiful blue color, and M. F. suggests the use of this film, deposited on the outer surface of the object-glass, as a substitute for colored glasses in the telescope. Experiment has shown that the effect is good, the definition being perfect, the color not inconvenient, and the eye relieved from all fatigue.

New Arrangement of the Galvanic Constant Battery.—The greatest inconvenience about the constant battery is the difficulty of filling and emptying it, which occupies a great deal of time, and is very troublesome and annoying. M. Zaliwski-Mikorski has invented an arrangement by which this trouble can be in a great measure avoided.

The permanent part is a wooden trough, lined with a mastic composed essentially of sulphur, to which is added a small quantity of tar and lamp-black to prevent cracking. Into this are inserted alternately partitions of porous material and of gas-coke. When the liquid is poured into one of these sections, it is transmitted to all the corresponding ones, and to these only, by means of a gutter arranged in the lower part of the trough, and the apparatus works at once, the force of the current increasing as the trough is filled.

When it is desired to empty it, a little more liquid is added, which charges a syphon whose external branch is movable by means of caoutchouc tubes, and the interior branch projects from the gutter; so that it is not necessary to move the trough to empty it.

The plates of zinc which are movable rest upon projections at the base of the cokes; so that the weight of the metal itself establishes communication. One or more of the plates may be withdrawn without destroying the current, which is merely weakened correspondingly.

Detection of Sulphuric Acid in Vinegar.—Böettger's *Polytechnisches Notizblatt* suggests a very simple, ingenious, and doubtless efficient method of detecting this very common and annoying falsification: Take about 50 cubic centimetres (1·7 fluid ounces) and boil it with a small quantity of starch until one-half the liquid has boiled away; after cooling add a drop of iodine. If sulphuric acid was present, the starch will have been converted into sugar, which will produce no color with iodine; but if no sulphuric acid be present, the starch will retain its properties, and give the characteristic blue color. Very little starch should be used in this test.

Hardness of Silver.—Mathey, in Dingler's *Polytechnisches Journal*, points out that the hardness of silver, which sometimes interferes seriously with the chasing, and gives a mat and gray cut, and which is generally attributed to metallic impurities, is really caused by the high temperature at which the silver has been cast. When the crucible is suffered to cool until a light solid crust forms on the surface of the fused

metal, before casting, a soft silver, with a brilliant cut, is always obtained.

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Preservation of Milk.—Mr. Williamson states that the germs to which he attributes the fermentation of milk will bear boiling under atmospheric pressure unharmed; but that under a pressure of one and a half atmospheres they are destroyed, so that after such boiling, milk may be preserved indefinitely in air-tight cans.

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Pine Wool.—Attention is again called to the discovery of M. Pannewitz, of Breslau, by means of which a species of flannel is made from the fibres of pine leaves which is now exclusively used in the hospitals, prisons, and barracks of Breslau and Vienna for bed-coverings. The flannel thus made has the advantage of driving away all insects; it serves for stuffing as well as horse-hair, and costs but one-third of that article; it will make all kinds of garments which are of great durability and comfortable warmth. The liquid from the manufactory is now used as a medicine, and the refuse of the works makes the gas by which they are lighted.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, November 28, 1866.

The meeting was called to order, with the President, Wm. Sellers, Esq., in the chair.

The minutes of the last meeting were read and approved.

The minutes of the Board of Managers were reported, including the following donations to the library: From the Chemical Society and the Society of Arts, London; the Adjutant General, the Smithsonian Institution, and F. Emmerick, Washington, D. C.; Prof. B. Howard Rand, A. R. Leeds, and T. D. Rand, Philadelphia; and the New Jersey Coal Company, South Amboy, New Jersey.

The various Standing Committees reported their minutes, together with a resolution of the Committee on Science and Arts, to whom was referred the question of a uniform system of danger signals.

Resolution passed by the Committee on Sciences and the Arts, at their meeting held May 23, 1866:

Resolved, That the Franklin Institute be requested to address a memorial to Congress, recommending the adoption of a uniform system of danger signals for all the railroads of the country.

This resolution, being regularly proposed and seconded, was adopted.

The various Special Committees reported progress.

The report of the Resident Secretary, on novelties in science and the mechanic arts, was then read, as follows:

Secretary's Report.

The Lenoir gas engine is now manufactured and supplied regularly in New York. Engines of from $\frac{1}{2}$ to 4 horse power are furnished

at prices varying from $400 to $1300, and the specified powers are guaranteed by the Lenoir Gas Engine Company, No. 435 East Tenth Street, New York. As this motor is no novelty to the scientific world, and has been often described already, we will only notice, in this place, a few points, by way of suggestion.

It is claimed that this engine does not act so much by reason of an explosion as by the mere heating of air in the cylinder, accomplished by burning the fuel (gas) in its midst.

These engines are largely used in Paris, and elsewhere, for pumping water, light printing, turning sewing machines, hoisting goods, lifting passengers and baggage at hotels, propelling street cars, raising stone and other building materials,—for which last purpose more than 80 gas engines are now used in Paris alone. The cleanliness, mobility, convenience, and safety of this instrument commends it to the use of those requiring a motor of moderate power for intermittent work. The point in which improvement seems to be most desirable is in the means employed for igniting the gas. The Ruhmkorff coil is now used for that purpose, but is open to some objection on account of its battery, &c. The excellent apparatus invented by Mr. Cornelius would undoubtedly subserve the required purpose, if electricity is essential, or the improvement of M. Pierre Hugon, noticed in our last report, where small gas jets do the work of the electric spark, might be adopted.

An improved bar vice, invented by Colonel P. G. Chorman. In this instrument the outer jaw is fixed, and is firmly united with the bed-plate, on which travels the inner and movable jaw. This last is drawn up by a long screw which passes through the outer or fixed jaw, as is usual in common vices, and works in a thread cut in the inner jaw. The advantages claimed are simplicity of construction and strength to resist concussion. This vice is, in fact, essentially an anvil, and will bear as much hammering as would an anvil of the same material. The effect of a blow upon the jaws, or work held between them, is transmitted to the bed-plate without bringing any strain upon the screw.

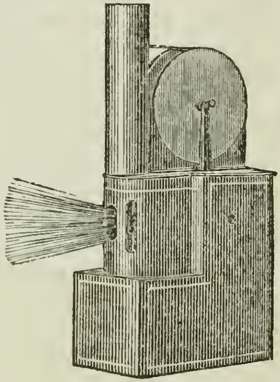
A safety-valve in connexion with kitchen range water-backs, by T. S. Speakman, Esq. This consists of a very compact safety-valve kept shut by a spiral spring, whose tension can be readily adjusted by means of a screw-cap, which can readily be attached to a water-back in such a manner that when the pressure reaches a dangerous point, it will give vent to the steam, so avoiding an explosion, which we know from experience may be of a very serious character.

A side-wheel propeller, by Mr. T. S. Speakman. This consists of a circular blade with a double inflection or returned spiral curve, which, being partially immersed and rotated, produces an action much like that of an oar when used for sculling. Experiments are now in progress, and a more full account will be given at a subsequent time.

The method of working the Atlantic Telegraph with an open circuit, by which all disturbing effects from earth currents were avoided, was fully explained by the aid of diagrams projected on the screen.

The improved signal system of A. F. Ward was exhibited in like manner.

The new magnesium lamp, improved and manufactured by the American Magnesium Company, of Boston, was then exhibited. This instrument is represented in the accompanying cut. The clock-work, by which the motion is produced, is enclosed in the square-shaped portion below, and at the back. In the rounded front, are the parts for feeding the ribbons, &c. These consist of two little rollers, between which the ribbon is passed, and regularly delivered by their motion. They are placed immediately over the front opening, at which the ribbon is ignited and burned. Below this opening work eccentric cutters, which nip off the ash thread from time to time. The ribbon is supplied from flat bobbins, represented at the top, from which it passes into the chimney and to the rollers. The whole structure is exceedingly compact, so as to fit easily a common magic lantern box. The most important novelty in this instrument is the arrangement of the chimney and draft. This is entirely closed below, with the exception of the opening shown directly in front of the flame. By this means *the draft blows directly into the face of the light*, thus sweeping off the smoke, and making the intensest light exactly where it ought to be. The efficiency of this arrangement is very easily proved by opening the door at the rear for removing the ashes, when the light will fall off to about half its former brightness. The practical performance of this instrument, as you now see, is of the most satisfactory character. (The lamp was lit, placed in a lantern, and used for about 20 minutes in the exhibition of various photographic views, without the least variation in light or need of adjustment, and was finally extinguished only because no further experiment with it was desired. The quality of the light was most excellent, comparing favorably with that of the best oxyhydrogen arrangement, and the steadiness of the flame all that could be desired for lantern exhibitions.)



An account of this improved lamp was sent, about three weeks since, to the editor of the *British Journal of Photography*, who, in his paper, No. 340, page 534, thus expresses his opinion: "On receiving Dr. Henry Morton's letter, in which the improvement was described, we lost no time in obtaining and testing a chimney similar to that described by him, and the result has proved most satisfactory.

"Mr. Solomon, who was present during the trial, and with whose lamp the experiment was performed, unhesitatingly expressed his opinion that, in consequence of this improvement, a light of equal intensity might be obtained from one ribbon of the metal as was formerly obtained from two. This, of course, expresses at once a saving of one-half, by the adoption of the new chimney. But, in addition to this, there are collateral advantages, such as increased steadiness, &c."

The absorption and dialytic separation of gases by colloid septa, by Thomas Graham. We find, in the Proceedings of the Royal Society, some very remarkable statements on the above subject, by the distinguished chemist designated.

It appears that a thin film of india rubber, though impervious to air while in its usual gaseous form, is capable of first liquefying the constituent gases of the atmosphere (O and N) in its pores, of then transfusing these liquids through its substance, (as it would chloroform or ether,) and, lastly, of allowing these liquids to evaporate again, or rather expand, into a gaseous form on the other side, if a vacuum be there produced.

The two gases named suffer these changes however, with unequal facility, oxygen passing two and a half times more rapidly than nitrogen. In other words, while all the oxygen contained in the air gets through, only half the nitrogen passes.

The gas passed through contains, therefore, 41·6 per cent. of oxygen, while air has but 21 per cent.

This dialysed air will rekindle wood burning without flame, and may be obtained by the use of a silk bag varnished with rubber or pure rubber balloon. The first prevented from collapse by layers of felted carpeting, and the last by a stuffing of sawdust, a vacuum being produced inside, in either case, by the use of an air-pump or Sprengel's air-exhauster. (See *Jour. Frank. Inst.*, Vol. LI., page 369.)

Palladium condenses gases in a wonderful manner similar to the above, as the same author remarks. Thus foil from the hammered metal condenses six hundred and forty-three times its volume of hydrogen at a temperature below 100° C. Platinum takes up 3·8 vols. Palladium will not however, absorb oxygen or nitrogen. Fusion, strange to say, reduces the capacity of both metals.

This property explains, in some degree, the wonderful porosity of platinum and iron tubes when heated, to hydrogen gas, lately noticed by MM. Deville and Troost.

A new process for the extraction of sugar, by Mr. Roberts, is described in *Engineering*, page 337, and is stated to have been applied with excellent success at Selowitz, in Austria, in making beet sugar. The saccharine plant is cut in slices, which are steeped in water, when the sugar passes out from their tissue by an action of osmose, leaving the colloid impurities, such as albumen, behind. The usual means are employed to make the extraction as thorough as possible with the least amount of water.

The absorption bands produced in the spectrum by vapor of water have been elaborately studied by Janssen, as we see from the *Comptes Rendus* of August 13. An iron tube, 120 feet in length, was used, filled with steam at 7 atmospheres pressure. Strong groups of lines were observed corresponding with D and A of the solar spectrum; beside a multitude of others, these lines especially abound in the blue part of the spectrum. Similar general conclusions to those obtained as above were published some time since by J. P. Cook. (See *Silliman's Journal*, Vol. XLI., page 178.)

Diffused sunlight is red, or has an excess of red light, according to Memorski, of Vienna, as we should anticipate from the absorptive action of vapor on the blue rays noted above.

The spectrum of comet of 1866, by William Huggins, Professor of the Royal Society.

On January 9, the spectrum of the comet was observed. The telescope and spectrum apparatus which were employed were those described in the article previously published, "On the Spectra of Some of the Nebulæ." The appearance of the comet was that of an oval, nebulus mass, surrounding a very minute and not very bright nucleus. The length of the slit of the apparatus was greater than the diameter of the telescopic image of the comet, and the appearance presented when the centre was placed in the middle of the slit, was that of a broad continuous spectrum fading gradually at both edges. Nearly in the middle of this spectrum, and about midway between *b* and *c* of the solar spectrum, a bright point was seen. The absence of breadth in this bright point, in a direction at right angles to that of dispersion, showed that this monochromatic light was emitted from an object of no sensible magnitude in the telescope, that it came, in fact, from the minute nucleus. This shows that the light of the coma differs from that of the minute nucleus. The nucleus is self-luminous, and is composed of ignited gas. The continuous spectrum of the light of the coma indicates that it shines by reflected solar light. We know from observation that the comæ and tails of comets are formed from matter contained in the nucleus. The usual formation of the tail appears to be, that as the comet approaches the sun, material is thrown off at intervals from the nucleus in the direction towards the sun. This material is not at once driven into the tail, but usually forms, in front of the nucleus, a dense luminous cloud, into which the bright matter of the nucleus continues to stream. In this way a succession of envelopes may be found, the material of which afterwards is dissipated in a direction opposite to the sun, and forms the tail. Between these envelopes dark spaces are usually seen. The light of the comet was feeble, and the continuous spectrum made it difficult to detect lines. A cylindrical lens was used; but only the bright line already described was seen. In the paper "On the Spectra of the Nebulæ," it was shown that this bright line corresponded with the brightest lines of nitrogen, and this may indicate that cometary matter consists principally of nitrogen or of some elementary substance existing in nitrogen.

"**Further observations on the spectra of some of the nebulæ** with a mode of determining the **brightness of these bodies**" from the same authority as above.

The results already presented are confirmed by new observations, namely, that clusters and nebulæ give either a continuous spectrum or a spectrum consisting of one, two, or three bright lines. The positions of these lines are the same as those of the bright lines of the nebulæ before described. Some of these spectra appear irregularly bright in some parts of the spectrum. Analysis by the prism shows that some of the nebulæ consist of luminous gas, existing in masses,

which are properly continuous, and the nebulæ in the telescope present not points but surfaces, in some cases subtending a considerable angle.

By means of a special apparatus, the light of three nebulæ was compared with the light emitted by a sperm candle burning at the rate of 158 grains per hour. The results are—

The intensity of nebula, No. 46,281, H 4 = $\frac{1}{1508}$ part of that of the candle.
" " annular nebula in Lyra. = $\frac{1}{6032}$ " "
" " dumb-bell nebula = $\frac{1}{19604}$ " "

The estimation in each case refers to the brightest part of the nebula. The amounts are too small by the unknown corrections needed for the loss which the light has sustained in its passage through space, and through the earth's atmosphere. These values have an importance in connexion with the gaseous nature of the source of the light, which the spectroscope indicates. Similar estimates, made at considerable intervals of time, might show whether the brightness of these bodies is undergoing increase, diminution, or a periodic variation.

The viscosity or internal friction of air and other gases, by J. C. Maxwell, Proceedings of the Royal Society. All bodies are capable of having their form indefinitely altered, and those which resist the change of form with a force depending on the rate of deformation may be called viscous bodies.

Various experiments have been made on the viscosity of elastic solids and gases by others, but the author has investigated the laws of viscosity in air by causing three disks, interposed between four other fixed disks, to turn about a vertical axis by means of a steel suspension wire. During the oscillations of the movable disks, the viscosity of the air in the six strata caused a diminution of the amplitude of oscillation which was measured by means of the reflection of a scale in a mirror. The apparatus was in an air-tight case. The observed diminution in the arc of oscillation was partly owing to the viscosity of the suspension wire, but this was eliminated by a series of experiments. The conclusions drawn from the experiments agree, as far as they go, with those of Mr. Graham, "On Transpiration of Gases." They are as follows:

1. The co efficient of viscosity is independent of the density, the temperature being constant.

2. The co-efficient of viscosity increases with the temperature.

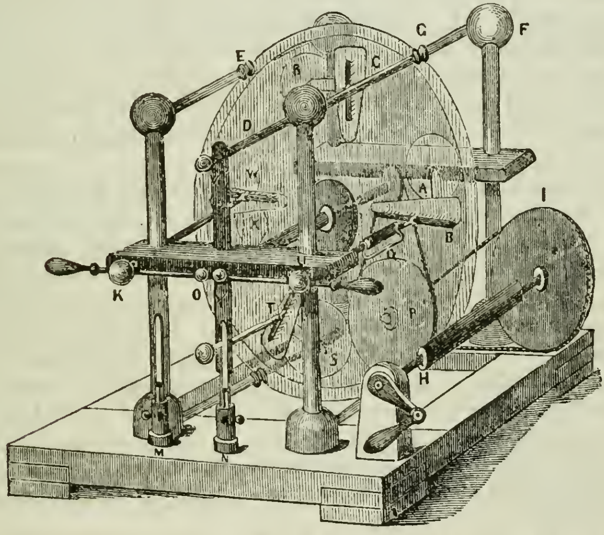
3. The co-efficient of viscosity of hydrogen is much less than that of air.

4. The ratio for carbonic acid was found to be 859. Graham makes it 807. Graham's calculation is supposed to be the most correct.

5. Experiments on dry air were tried to ascertain whether any slipping takes place between the glass and the air in contact with it. If such action took place its amount was unappreciable.

Some new facts with regard to the Holtz machine were then stated by the Secretary as the result of his own observations. The machine exhibited and described on a previous occasion was found to operate in a very satisfactory manner for some days, but suddenly, without any evident cause, failed entirely, (though the weather was very dry and cold,)

to yield anything more than the most insignificant and feeble sparks. This failure led to a long course of experiments, the result of which has been to show that for efficient working the strips of paper attached to the fixed disk should be very slightly insulated on their surfaces, but as thoroughly as possible upon their edges. The cause of failure being the electric penetration of the insulation at the rear edge of the paper, a few words as to the theory of the machine in this connexion will make this matter plain. As was shown in a previous report, (see this *Journal*, Vol. LII., page 282,) the card points A S X R are constantly feeding the respective strips B T W C, to which they are attached, with electricity. If these papers were perfectly insulated on their surfaces and edges they would act like so many Leyden jars, the paper answering to the inner coating, the insulating material to the glass, and the constant current of air moving between the plates playing the part of



an outer coating connected with the ground, by constantly removing one kind of electricity and supplying the other. The charge in the paper would then continue to accumulate without any limit other than the resistance of the insulating material, which must soon yield, and a spark penetrating this, all capacity for retaining a charge is at once lost, as in a ruptured Leyden jar, and the electricity supplied by the paper point at once leaks out through the perforation, and, descending upon the revolving plate, neutralizes the opposite sort of electricity there presently developed, and so prevents the charging of the paper point and strip next in order, thus interrupting the action of the machine.

If, however, the surface of the paper is not well insulated, a diffused leakage takes place all over it, which does not cause the whole charge to be lost, but acts as an overflow after a certain tension has been reached. This leakage, beside, occurs directly opposite the brass combs, and causes a corresponding increase in the amount of opposite electri-

city which these are delivering upon the revolving plate. If this leakage occurred upon the edge of the paper, it would be out of range with the combs, and would not thus tend to compensate the mischief it does.

The tension of the fluids is, of course, greatest at the edge of the papers; these should therefore be well insulated to prevent all 'concentrated leakage.' This may be best done by shellac varnish applied in a narrow line on the edge, any broad band of insulation tending to develop the sort of action described above. We consider the facts here stated of importance, because without a knowledge of them, this otherwise most efficient machine becomes almost worthless, being liable to fail at any moment. Such was the condition of the machine now exhibited when received from its manufacturer, Ruhmkorff. It was merely a question of time and use, as to how soon it would give out and become useless, and clearly nothing was known by its manufacturer or inventor as to a means of repairing it, (if even this weak point was recognised,) for no hint is given of either in very voluminous publications on the subject of this machine. If, however, we give an excess to the insulation of the papers at their edge, the liability to failure is greatly reduced, and if this should occur by cracking of varnish or mechanical wear, a coat of shellac, which may be applied and rendered dry in a few minutes, will correct the evil.

The machine now exhibited was, an hour since, perfectly useless, owing to the cracking of some varnish used as an experiment, but was restored in about 20 minutes to its present satisfactory condition.

Attention was directed to the fact, not mentioned in the previous report, that, by connecting the two horizontal brass combs and balls, leaving the upper and lower ones insulated, and charging the machine as usual, sparks could be taken from the upper ball on D exactly as from the prime conductor of an ordinary machine, and all the usual apparatus illustrating attraction and repulsion, most efficiently worked. A battery of Leyden jars charged in this way, in half a minute, by 30 turns of the handle H, had one of its jars ruptured, though it had been before repeatedly charged with 500 turns of an ordinary 30-inch plate machine without injury.

The essential principle of agaric, prepared by Thomas J. Brown, of Philadelphia, was exhibited. It was obtained as follows: The natural fungus was treated with hot alcohol; the solution so obtained was then further treated with sub-acetate of lead and litharge and filtered, then acted upon by sulphuretted hydrogen, again filtered and twice evaporated and redissolved. The substance so obtained crystallized in minute translucent needles, almost colorless, but yielding a faint yellow tint when in mass.

The solution in pure alcohol did not fluoress, nor did an addition of water and sulphuric acid develop in it this action. An alcoholic solution of quinine also gave no fluorescence even when diluted with water, but acquired this property on the addition of a few drops of sulphuric acid.

Phosphorus may be crystallized by sublimation in an atmosphere of nitrogen, as M. Blondlot has shown, and then forms minute white cubes, which acquire a ruby color on exposure to light.

Mineral springs, like those of Saratoga, have been discovered near Harrisburg, Pennsylvania.

A lime light has been placed on a tower in the centre of Hyde Park, and is to be used for general illumination.

A bed of peat, fifteen inches thick, and covering 1500 acres, has been discovered near Des Moines, Iowa.

A vein of fine slate was recently discovered in Fluvanna county, Virginia. It is said to equal the celebrated Buckingham slate, which took the premium at the World's Fair.

Lead in great abundance has been discovered in the valley of the Green River, in Kentucky. A mine will be opened at once. Similar discoveries are reported in Owen and Shelby counties.

The San Antonia Herald says, the accounts of rich deposits of gold in the vicinity of Los Pinos Altos, in southern New Mexico. are confirmed. The proceedings on the Gila have been very successful.

A house having nine stories above the ground-floor, and with basement and cellars eleven stories, is in course of construction at Paris, in the Quartier de Roule. The lodgers on the upper stories will be raised on a platform ascending noiselessly every minute, and raised by hydraulic power.

In France a steam carriage for towing boats and barges in rivers and on canals has been invented. It was tried a few days since on the river Oise, and was found to answer perfectly. Running on the towing-paths it makes ascents and descents and turns as easily as horses do.

The Secretary then called attention to some printed rules for prompt treatment in case of accidents, such as might occur to those employed about machinery, and requested Dr. Packard, by whom the rules were prepared, to make further examinations. Dr. Packard then remarked as follows:

"When accidents take place on railroads, or in factories or machine shops, as they will in spite of every care, it not unfrequently happens that the persons injured suffer greatly, or even lose their lives, because no one present knows exactly what ought to be done at once, before a surgeon can be had. In the course of the last sixteen years, I have seen repeated instances of this kind; and one which came under my notice last summer so impressed me, that I determined to try to do something for the mitigation of the evil.

"I have therefore prepared a set of rules, as to the course to be pursued in such injuries as cause shock or collapse, or loss of blood, and as to the mode of carrying an injured person comfortably. These I propose to furnish on a card or sheet, 14½ inches by 21, at the cost of paper and printing. They have been tested by submitting them to the scrutiny of railroad men, and brought down to the greatest simplicity. Nearly 4000 of these have been distributed, and are now in use on different railroads. It is not proposed to post them before the public, but in the private offices, tool-houses, baggage-cars, etc., so that they may strike the eye of the employés who are to be guided by them.

"The similar papers headed 'Injury by Machinery' are intended for

use in factories and machine shops. Here, however, a much smaller number would be required for each establishment, and cards might be conveniently used instead of papers. I should be glad to supply either set of rules, at such a cost as will cover my own expenses, to any one desiring them." These cards can be obtained by addressing the author, at 1415 Spruce Street.

The meeting was then, on motion, adjourned.

HENRY MORTON, *Secretary.*

BIBLIOGRAPHICAL NOTICES.

Memoirs of the National Academy of Sciences. Quarto. Washington: Government Printing Office, 1866.

The National Academy of Sciences was chartered by the government of the United States for the purpose of advising the government in matters depending on the application of science, and making such experimental researches as should be needed for government uses. In addition to a considerable number of important investigations and reports made by its committees, we have in the volume now before us the first instalment of their memoirs, and it must be admitted that, although few in number, they are of a very high character of merit, and rank the Academy creditably with its European sisters.

The first memoir is *the Reduction of the Observations of Fixed Stars, made by Le Paute D'Agelet*, in 1783–85, by B. A. Gould. This embodies the result of a very laborious investigation, by means of which a very large catalogue of star observations, which were not heretofore available for astronomers' use, in consequence of the undetermined errors, have been revised and corrected, and made available. It is quite curious to see how, after an interval of some eighty years, the errors of graduation and defects of form of the instrument used, can be ascertained and determined, and the results eliminated from the observations so as to make them comparable with more modern labor. Astronomers only can appreciate the immense benefit of Prof. Gould's labors; but any person of ordinary mind and education can appreciate the ingenuity and acuteness necessary to develop such results.

This, which is the longest of the memoirs, and extends to 261 pages, is followed by an investigation by Prof. Peirce, *On the Theory of the Saturnian System*, in which was discussed the conditions of equilibrium of the rings of the planet, and their dependence on the satellites demonstrated. If any one wants to whet his mental appetite by a taste of the modern mathematics, we recommend these twenty-four pages to his particular attention. This is followed by a short memoir of but four pages by the late Augustus A. Gould, M. D., "*On the Distribution of certain Diseases in Reference of Hygienic Choice of Location for the Cure of Invalid Soldiers.*" This paper will be found more generally readable than abstract mathematics. It presents an interesting table of the statistics of consumption, and shows the importance of attending to vital statistics more generally and closely than has hitherto been done.

Professor Norton, of Yale College, gives us at length his theory of shooting stars, and it may possibly console some of the unfortunates who lost a night's sleep in looking for the predicted shower. to learn here the grounds on which the prediction was made, and what the prediction really was—which will be found to differ somewhat from the newspaper accounts. Finally, the volume closes with an elaborate memoir by Prof. Bartlett, of West Point, "*On Rifled Guns*," the strains to which they are subjected, the materials from which, and the dimensions of which, they ought to be made. If we are not mistaken, this will prove to be a classical treatise upon this subject, and one to be referred to by all interested in ordnance hereafter.

In conclusion, we congratulate the Academy on the amount of thoroughly good work here set forth, and hope that they will not, as they grow older, weary of well-doing.

Peat and its uses as Fertilizer and Fuel. By SAMUEL W. JOHNSON. Professor of Analytical and Agricultural Chemistry, Yale College. Fully illustrated. 18mo., pp. 168. New York: Orange, Judd & Co.

In this little work, Professor Johnson has given us a very full and valuable account of a material which is forcing itself into notice in consequence of the high price of coal and other fuel. In this treatise he explains, first, the origin of peat, its chemical composition and physical and chemical properties. He then explains and discusses its uses as a manure, its effect on various soils and under different climates, and its mode of preparation for such purposes. Afterwards he goes very fully into the subject of the use of peat for fuel, and describes, with drawings, the various machines which are used for its preparation. He also treats of its use as a means of obtaining illuminating gas. The high reputation of Professor Johnson is sufficient guarantee that the work thus laid out has been ably and conscientiously done, and we recommend this little book to our readers as very valuable, not only as a special treatise upon its subject matter, but as a model for other treatises upon similar subjects.

Warming and Ventilating the Capitol.

It appears that the House of Representatives called upon the Secretary of the Interior for a report from the architect, upon the warming and ventilation of the Capitol. Mr. Walter had already availed himself of the assistance of Professor Henry and Dr. Charles M. Wetherill to institute a series of experiments upon the result of the system, and the result is the present report by Dr. Wetherill upon the subject. His conclusions, that the amount of ventilation compares favorably with the best of similar attempts in Europe, that the air is introduced in sufficient quantity without inconvenient drafts, and at a proper temperature, but is deficient in hygrometric moisture, are interesting more or less to all of us. But what will or ought to interest us more, is the great mass of information upon the general subject, which appears to be for the most part unknown, misconceived, or neglected among us. In this respect the labors of Dr. Wetherill are invaluable, and some Sanitary Commission, Board of Health, or other official body ought to see to republishing this report in a large edition and disseminating it widely among our citizens

A Comparison of some of the Meteorological Phenomena of OCTOBER, 1866, *with those of* OCTOBER, 1865, *and of the same month for* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	October, 1866.	October, 1865.	October, for 16 years.
Thermometer—Highest—degree, .	75·00°	78·00°	90·00°
" date, .	2d. & 8th.	10th.	4th, '58.
Warmest day—mean,	67·00	73·17	78·30
" " date,	2d & 22d.	10th.	6th, '61.
Lowest—degree, .	37·00	37·00	28·00
" date, .	5th.	25th.	25th, '56.
Coldest day—mean,	45·33	44·83	35·80
" " date, .	5th.	25th.	27th, '59.
Mean daily oscillation,	13·55	11·23	15·17
" " range, .	5·60	5·13	5·42
Means at 7 A. M., .	52·47	52·55	51·35
" 2 P. M., .	62·34	60·15	62·81
" 9 P. M., .	55·47	54·85	55·32
" for the month,	56·76	55·85	56·49
Barometer—Highest—inches, .	30·326 ins.	30·225 ins.	30·452 ins.
" date, . .	6th.	30th.	25th, '61.
Greatest mean daily press.	30·302	30·209	30·378
" " date, .	5th.	30th.	25th, '61.
Lowest—inches, . .	29·425	29·155	29·012
" date, . .	30th.	15th.	26th, '57.
Least mean daily press.,	29·506	29·226	29·059
" " date, .	30th.	19th.	26th, '57.
Mean daily range, .	0·147	0·171	0·144
Means at 7 A. M., .	29·931	29·778	29·907
" 2 P. M., .	29·870	29·746	29·865
" 9 P. M., .	29·911	29·786	29·893
" for the month, .	29·904	29·770	29·888
Force of Vapor—Greatest—inches,	0·611 in.	0·527 in.	0·731 in.
" date, .	2d.	11th.	7th, '61.
Least—inches, .	·112	·094	·065
" date, .	25th.	28th.	21st, '59.
Means at 7 A. M., .	·326	·293	·315
" 2 P. M., .	·322	·281	·339
" 9 P. M., .	·345	·298	·325
" for the month,	·331	·291	·326
Relative Humidity—Greatest—per ct.,	96·0 per ct.	94·0 per ct.	97·0 per ct.
" date,	13th.	18th.	often.
Least—per ct.,	31·0	34·0	23·0
" date, .	5, 15, & 25,	29th.	21st, '59.
Means at 7 A. M.,	78·7	70·5	77·7
" 2 P. M.,	54·5	51·7	56·0
" 9 P. M.,	74·1	66·5	72·9
" for the month	69·0	62·9	68·9
Clouds—Number of clear days,* .	11	11	9·8
" cloudy days, .	20	20	21·2
Means of sky cov'd at 7 A. M.,	61·6 per ct.	51·0 per ct.	56·6 per ct.
" " " 2 P. M.,	56·1	57·1	55·7
" " " 9 P. M.,	42·6	38·1	40·0
" " for the month	53·4	48·7	50·8
Rain—Amount, ...	3·538 ins.	3·358 ins.	2·928 ins.
No. of days on which rain fell, .	8	6	8·8
Prevailing Winds—Times in 1000,	N 54°41′ W ·168	N 77°35′ W ·293	N 73°18′ W ·237

* Sky one-third or less covered at the hours of observation.

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